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HOST-SPECIFICITY OF *CYRTOBAGOUS SALVINIAE* CALDER & SANDS (COL., CURCULIONIDAE) INTRODUCED INTO INDIA FOR THE CONTROL OF *SALVINIA MOLESTA*

K. P. JAYANTH & SUDHA NAGARKATTI*

All India Coordinated Research Project on Biological Control of Crop Pests and Weeds, Indian Institute of Horticultural Research, Bangalore, India 560 089

(Received 7 August 1985)

The host-specificity of *Cyrtobagous salviniae* Calder & Sands (Col. Curculionidae), imported for biological control of the aquatic weed *Salvinia molesta* in India, was studied. Seventy five species of plants representing 41 families were tested. The weevil did not feed or reproduce on 67 of the test plants. Extremely limited feeding was observed on *Amorphophallus* sp., *Colocasia esculenta*, *Ipomaea batatas*, *Lactuca sativa* and *Raphanus sativus*, with slightly more on *Pistia stratiotes* and *Trapa bispinosa*; but damage was negligible and no oviposition occurred on any of these plants. In the presence of *Salvinia*, none of the above plants were attacked, clearly showing that *C. salviniae* safe for introduction. Following these studies, *C. salviniae* was introduced into a lily pond at Bangalore and field releases were also initiated in Kerala. The weevil is now established as evidenced by the presence of all immature stages and freshly emerged adults.
(Key words: Cyrtobagous salviniae, Salvinia molesta, Biological control)

INTRODUCTION

The free-floating aquatic plant ***Salvinia molesta*** Mitchell is native to Brazil (FORNO & HARLEY, 1979) and is believed to have spread to Asia and Africa through introduction into botanical gardens. *Salvinia* was first observed in Kerala in 1955 and since 1964 has assumed pest status (JOY, 1978). According to JOY the weed is now present all over Kerala and in the Kuttanad district alone some 75,000 acres of canals, rivers, ponds and other water bodies are infested. Navigation and irrigation are adversely affected, besides fishing, and other operations requiring unimpeded flow of water. In some areas cultivation of paddy is abandoned on account of *Salvinia* infestation. Efforts to introduce ***Paulinia acuminata*** DeGeer in Kerala have not been successful, the grasshopper being subject to predation by frogs, toads, spiders etc. (JOY *et al.*, 1981), although it was considered a potential control agent by FORNO (1981).

Cyrtobagous salviniae CALDER & SANDS (earlier believed to be *singularis* Hustache), a weevil belonging to the aquatic tribe Bagoini, was one of three insects recommended by BENNETT (1966). Introduction of this insect originating from South-eastern Brazil into Lake Moondarra covering 400 ha in northern Queensland (Australia) in June 1980, resulted in complete control of the weed within 18 months (ROOM *et al.*, 1981). SANDS (1983)

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* Present address : 11130 Blue Heron Drive, Pineville, N. C. 26134, U. S. A.

reported that the weevil population originating from Brazil differs from *C. singularis* collected from Trinidad by BENNETT (1966) and was later identified as *C. salviniae* (CALDER & SANDS, 1985). A stock of this weevil was received from Australia through the courtesy of Dr. K. L. S. HARLEY of Long Pocket Laboratories, Indooroopilly, Australia. The insect culture was established in quarantine at Bangalore and host-specificity tests were carried out to reconfirm the tests that had earlier been carried out by the Indian Station of the Commonwealth Institute of Biological Control, Bangalore (SANKARAN & RAMASESHAIAH, 1973).

MATERIALS AND METHODS

The shipment of *C. salviniae* was received in July 1982. Ten adults were released on yong plants of *Salvinia* held in 20 × 16 cm clear plastic jars half filled with water and with lids suitably modified to provide aeration. After 5–7 days, the adults were collected back and released on fresh plants and the process repeated until they died. The exposed plants were held in 61×40.5×30.5 cm opaque plastic troughs filled with water collected from an outdoor tank. The troughs were kept covered with cloth cages provided with aeration holes covered with nylon mesh sleeves for easy handling and polythene sheeting at the top to admit light, the whole being supported on a wrought iron frame.

Seventy-five species of plants representing 41 families were each exposed to freshly emerged adults of *C. salviniae* sp. for host-specificity tests. For the no-choice tests (in which individual plants were tested in the absence of the natural host), bouquets of the test plant were placed in plastic jars, with the stems dipping in water contained in small vial and with a cotton wick projecting from the vial to provide free water for the adults to feed on. Aquatic test plant were held directly in water. Five adults were released per plant and observations were recorded until they died. Yellowing or decaying plants were replaced whenever required.

Observations were recorded on survival, feeding and oviposition. In the multiple-choice tests, all plants on which some nibbling or feeding had been observed were provided together with a single *Salvinia* plant. The tests were replicated three times.

RESULTS AND DISCUSSION

Under laboratory conditions, *C. salviniae* completed development in about 45 days. Adult weevils survived upto 60 days, feeding on tender leaves and making circular feeding holes. Newly emerged adults were unable to survive in the absence of fresh growth of *Salvinia*. Eggs were laid within the plant tissues or suspended in the root mass. The larvae mined through the stolons and leaf axils causing rapid decay and degeneration of the plants.

C. salviniae did not feed or oviposit on any of the 67 plants listed in Table 1, even though they survived for 6 to 30 days. Slight nibbling was observed on 8 plants (Table 2). One feeding spot was observed on *Amorphophallus* sp., and 2–5 spots on *Colocasia esculenta*, *Ipomaea batatas*, *Lactuca sativa* and *Raphanus sativus*. Among the aquatic plants, 3 feeding spots were observed on *Nymphaea* sp. There were more feeding spots on *Pistia stratiotes* and *Trapa bispinosa*, but damage to the plants was negligible. Also, oviposition did not occur on any of the above plants.

In the multiple choice tests feeding was observed only on *Salvinia*, indicating that in the presence of the natural host, none of the test plants on which nibbling was observed in a no-choice situation would be attacked. Earlier studies at the C I B C West Indian Station (BENNETT, 1966) and Indian Station (SANKARAN & RAMASESHAIAH, 1973) had also indicated that the weevils would not feed on or

TABLE 1. Test plants on which feeding by *C. salviniae* was not observed.

S. No.	Family	Species	Common name	Max. No. of days survived
1	Amaryllidaceae	*Polyanthes tuberosa*	Tube rose	13
2	,,	*Amaryllis* sp.	Easter-lily	8
3	,,	*Hymenocallis* sp.	Spider-lily	13
4	Anacardiaceae	*Mangifera indica*	Mango	13
5	Anonaceae	*Anona squamosa*	Custard apple	10
6	Araceae	*Syngonium* sp.	—	10
7	Begoniaceae	*Begonia* sp.	—	17
8	Bromeliaceae	*Ananas comosus*	Pineapple	13
9	Cannaceae	*Canna indica*	—	20
10	Caricaceae	*Carica papaya*	Pappaya	17
11	Chenopodiaceae	*Beta vulgaris*	Beet root	17
12	Commelinaceae	*Tradescantia fluminensis*	—	10
13	,,	*Zebrina pendula*	—	17
14	Compositae	*Helianthus annuus*	Sunflower	10
15	Cruciferae	*Brassica juncea*	Mustard	9
16	,,	*B. oleracea*	Cabbage	10
17	Cucurbitaceae	*Cucurbita maxima*	Pumpkim	8
18	,,	*Cucumis sativus*	Cucumber	12
19	,,	*Citrullus vulgaris*	Water melon	7
20	Euphorbiaceae	*Ricinus communis*	Castor	12
21	,,	*Codiaeum variegatum*	Croton	10
22	,,	*Manihot utilissima*	Tapioca	17
23	Graminaceae	*Oryza sativa*	Rice	18
24	,,	*Eleusine coracana*	Ragi	8
25	,,	*Triticum vulgare*	Wheat	9
26	,,	*Sorghum vulgare*	Jowar	7
27	,,	*Bambusa tulda*	Bambo	7
28	,,	*Zea mays*	Maize	8
29	,,	*Saccharum officinarum*	Sugarcane	24
30	Hydrocharitaceae	*Vallisneria* sp.	—	16
31	,,	*Hydrilla* sp.	—	14
32	Labiatae	*Mentha arvensis*	Mint	6

(Contd.....)

S. No.	Family	Species	Common name	Max. No. of days survived
33	Leguminosae	*Dolichos lab lab*	Lab lab	8
34	,,	*Arachis hypogea*	Groundnut	8
35	,,	*Pisum sativum*	Pea	8
36	,,	*Vigna sinensis*	Cowpea	8
37	,,	*Albizzia lebbek*	—	8
38	Liliaceae	*Allium cepa*	Onion	9
39	Malvaceae	*Abelmoschus esculentus*	Bhendi	10
40	,,	*Gossypium arboreum*	Cotton	21
41	Moraceae	*Artocarpus heterophyllus*	Jack fruit	8
42	,,	*Ficus carica*	Fig	12
43	Myrtaceae	*Psidium guajava*	Guava	8
44	Oleraceae	*Jasminum nudiflorum*	Jasmine	10
45	Orchidaceae	*Vanilla fragrans*	Vanilla orchid	30
46	Palmaceae	*Cocos nucifera*	Coconut	8
47	,,	*Araca catechu*	Beetlenut	8
48	Parkeriaceae	*Azolla pinnata*	—	30
49	Piperaceae	*Peperomia* sp.	—	8
50	Punicaceae	*Punica granatum*	Pomegranate	6
51	Rosaceae	*Rosa alba*	Rose	19
52	Rubiaceae	*Coffea robusta*	Coffee	10
53	Rutaceae	*Citrus media*	Lime	10
54	,,	*Murraya exotica*	Curry leaf	12
55	Sapotaceae	*Achras zapota*	Sapota	9
56	Scitamineae	*Musa paradisiaca*	Banana	8
57	Solanaceae	*Solanum tuberosum*	Potato	9
58	,,	*S. melongena*	Brinjal	8
59	,,	*Capsicum annum*	Chilli	10
60	,,	*Lycopersicon esculentum*	Tomato	9
61	Theaceae	*Thea sinensis*	Tea	7
62	Umbelliferae	*Coriandrum sativum*	Coriander	10
63	,,	*Daucs carota*	Carrot	7
64	Vitaceae	*Vitis vinifera*	Grape	10
65	Zingiberaceae	*Zingiber officinale*	Ginger	7
66	,,	*Curcuma longa*	Turmeric	11
67	,,	*Elettaria cardamomum*	Cardamom	18

TABLE 2. Test plants on which nibbling by *C. salviniae* was observed.

S. No.	Family	Species	Common name	Max. No. of days survived	No. of feeding spots observed
1.	Araceae	*Amorphophallus* sp.	Yam	7	1
2.	,,	*Colocasia esculenta*	Arvi	8	3
3.	,,	*Pistia stratiotes*	—	17	18
4.	Convolvulaceae	*Ipomoea batatas*	Sweet potato	28	5
5.	Compositae	*Lactuca sativa*	Lettuce	10	2
6.	Cruciferae	*Raphanus sativus*	Radish	25	5
7.	Nymphaceae	*Nymphaea* spp.	Water lily	9	3
8.	Onagraceae	*Trapa bispinosa*	Water chestnut	18	10

complete development in any plant other than *Salvinia*. Subsequent tests carried out in Australia (FORNO *et al.*, 1983) also confirmed this. It was therefore concluded that *C. salviniae* is incapable of reproducing on any of the test plants, other than *S. molesta*.

Permission of the plant protection Adviser to the Government of India was obtained in September 1983 for field trials and 785 adults were released in a *Salvinia* infested lily pond at the Lalbagh Botanical Gardens in Bangalore. Establishment of the insect under field conditions was observed by January 1984, as evidenced by the presence of larvae, pupae and freshly emerged adults. A nucleus culture of *C. salviniae* was also supplied to Dr. P. J. JOY of the Kerala Agricultural University at Trichur for breeding and subsequent field trials in Kerala. In a personal communication to the second author of this paper Dr. JOY (1985) has mentioned that *C. salviniae* is proving to be a great success and is now spreading to the vast stretches of Kuttanad in the Alleppey district of Kerala. In a subsequent study ROOM *et al.*, (1984) found that establishment of *C. salviniae* could be achieved with the release of as few as 200 adults and that the shortest time for damage to be caused was 4 months. They also found that establishment occurred in areas where nitrogen concentration was 1.18–1.82% of dry weight of the weed and where temperatures ranged from 0–45°C. Establishment occurred in 7 of the 8 sites where releases were made.

The biological control efforts against *Salvinia* are a clear indication of the potential that this method of control holds for weed control in India. Moreover, it should help to allay fears of introducing insect natural enemies of weeds into the country, particularly when the natural enemy in question has been throroughly studied and proven to be safe to cultivated crops. Although it is too early to say that *Salvinia* control in India will be as spectacular as it was in Australia, there is reason to believe that the project is certainly going in that direction.

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PROTEIN AND GLYCOGEN CONTENTS OF THE ACCESSORY REPRODUCTIVE GLANDS OF THE MALE AND FEMALE SILK MOTHS *BOMBYX MORI* BEFORE AND AFTER MATING

S. H. BHOSALE, V. L. KALLAPUR & K. VENKATESH*

Department of Zoology, Karnatak University, Dharwad, India 580 003
* Department of Entomology, North Carolina University, North Carolina, U S A

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The accessory reproductive glands (ARGs) of the mated male silk moth show highest concentration of total protein when compared to the testis, vas deferens, seminal vesicle and ejaculatory duct. The protein level of the ARGs show significant depletion after mating. The gravid female silk moth shows significant increase of the protein content of the accessory reproductive structures after mating. It is believed from these observations that the male proteins are transferred to the female during copulation. Using ^{14}C-leucine, it is possible to demonstrate that the male transferred proteins are stored in the accessory reproductive structures of the mated female. Glycogen appears to be the chief source of energy during mating in the male, whereas it serves as source of energy during ovulation process in the female moth.

(Key words: Protein, glycogen, accessory male and female reproductive glands, silk moths, *Bombyx mori)*

INTRODUCTION

Several studies have shown that the proteins from the male accessory reproductive glands (ARGs) are transported during copulation (LEOPOLD *et al.*, 1971; TERRANOVA *et al.*, 1972; KAULENAS, 1976; CHEN, 1984). It is known that the male ARGs produce the proteins which are used in the assembly of spermatophore, a structure which serves as the vehicle for the transfer of sperm from male to female (WIGGLESWORTH, 1936). Studies from other insects have indicated that material transferred by the male to the female during copulation either in the form of spermatophore or as seminal secretions may be used as source of nutrient by the female (LEOPOLD, 1976). This is of particular importance to the lepidopteran species which do not feed during adult life. The accessory secretion was found to stimulate oviposition in the female (CHEN, 1984) and was involved in the cytolysis of the female vaginal pouches which occur during copulation (LEOPOLD *et al.*, 1971; TERRANOVA *et al.*, 1972). Thus, the male accessory secretion transferred during copulation seems to have an important role in the regulation of the physiology of the female and may contain several stimulatory substances. The present study examines the protein content of the male and female ARGs of the silk moths *B. mori* before and after mating. The present opportunity was also availed of to study the glycogen level of the ARGs and its role as a source of energy during copulation.

MATERIALS AND METHODS

The adults of the silk moths *B. mori* (NB_4D_2) were obtained from laboratory culture. Male moths were placed with virgin females and as mating began, each pair was placed in a separate container. After 3 h copulation, some pairs were forcibly separated and the ARGs were carefully removed from the male and female moths for the determination of total proteins and glycogen contents. The remaining mated females were allowed to lay eggs. The ARGs of the female moth were removed after the completion of the egg laying. Likewise the ARGs of the unmated male and female moths were used for the estimation of proteins and glycogen.

The protein content of the ARGs was precipitated by the addition of 30% trichloro acetic acid (TCA) solution, followed by centrifugation at 3000g for 10 minutes at 20°C. The precipitate was washed twice with the same volume of TCA solution and dissoloved in 1ml of 0.1N NaOH. Known aliquots of this solution was used for the protein determination according to the method of LOWRY *et al.* (1951) using bovine serum albumin (fraction IV, Sigma Chemical Company, U S A) as reference standard. Incorporation of (U-^{14}C) leucine into the ARGs was essentially similar to that described by FRIEDEL & GILLOT (1977). Five microliter of laballed leucine was injected into each insect (specific activity, 350.0 mCi/m mole). After one hour of incubation time the radioactive males were allowed to mate with females for three hours after which some pairs were forcibly separated. Males and females were dissected under cold *Bombyx* saline (YAMAOKA, *et al.*, 1971). The various reproductive structures were removed and processed for the determination of radioactivity in the protein according to the method described by MANS & NOVELLI (1961). The radioactivity was measured on Beckman Liquid Scintillation Counter. The efficiency of the counter for ^{14}C was more than 90 per cent. The glycogen content of the ARGs was estimated following the precipitation of glycogen from a saturated solution of sodium sulfate with absoulte ethanol. Glucose was used as reference standard. The procedure followed was essentially similar to that described by SEIFTER *et al.* (1950).

RESULTS AND DISCUSSION

The results are presented in Tables 1—4. It may be seen from the results outlined in Table 1 that in the unmated male, the ARGs show the highest concentration of proteins (668.14 μg) when compared to those of testis (390.17 μg), vas deferens (215.23 μg), seminal vesicle (163.41 μg) and ejaculatory duct (219.04 μg). It is also evident that the protein

TABLE 1. Protein content of the various reproductive structures of the male silk moth before and after mating.

Reproductive structure		μg / gland		% reduction	*P* value
		Unmated male	Mated male		
Accessory reproductive gland	(7)	668.14 ± 49.4*	444.92 ± 24.23	33.4	<0.005
Testis	(7)	390.47 ± 27.30	314.28 ± 17.02	19.51	<0.05
Vas deferens	(7)	215.23 ± 19.80	158.09 ± 14.07	26.54	<0.05
Seminal vesicle	(7)	163.41 ± 10.21	121.86 ± 12.07	25.42	<0.05
Ejaculatory duct	(7)	219.04 ± 15.83	170.14 ± 19.21	22.31	< 0.1

* The results indicate mean ± SE of seven experiments; number of insects used is indicated in parenthesis.

level of these reproductive structures is depleted after copulation (Tables 1 & 2). The ARGs show maximum depletion (33.4%) than those of testis (19.51%), vas deferens (25.54%), seminal vesicle (25.42%) and ejaculatory duct (22.31%). It is of considerable interest to note that the gravid female shows significant increase in the protein content of the accessory reproductive structures (Table 2). Bursa copulatrix of the mated female shows as much as 475% increase while spermatheca and accessory gland exhibited respectively 177.5% and 30.51% increase in the protein level. It is possible that the increased level of proteins in the female may be due to the stimulation of protein synthesis by the male factor (s) transferred during copulation or the proteins of the male accessory

TABLE 2. Protein content of the accessory reproductive structures of the female silk moth during reproductive cycle.

Accessory reproductive structure		μg / gland				
		Virigin female	Mated female before egg laying	% increase	Mated female after egg laying	% decrease
Accessory gland	(7)	892.53 ± 36.93	1164.91 ± 76.09 ($P<0.01$)	30.51	394.77 ± 49.66 ($P<0.001$)	66.11
Bursa copulatrix	(7)	77.77 ± 15.97	447.61 ± 28.03 ($P<0.001$)	475.6	313.21 ± 24.46 ($P<0.001$)	30.02
Spermatheca	(7)	63.48 ± 5.31	176.18 ± 6.63 ($P<0.001$)	177.5	81.93 ± 5.81 ($P<0.05$)	53.49

The results indicate mean ± SE of seven experiments.

TABLE 3. Recovery of U ^{14}C-leucine from the accessory reproductive structures of the unmated male, mated male and mated female of the silk moth *B. mori*.

Accessory reproductive structures	Radioactivity dpm / gland		Mated female
	unmated male	mated male	
Testis	10,020*	6230	—
Vas deferens	7,710	5926	—
Male ARG	10,748	6634	—
Seminal vesicle	7,165	5400	—
Ejaculatory duct	7,768	4473	—
Female ARG	—	—	2,931
Bursa copulatrix	—	—	3,219
Spermatheca	—	—	2,476
Ovary	—	—	—

* The resutls are mean of three experiments.

TABLE 4. Glycogen content of the accessory reproductive glands of male and female silk moth *B. mori*.

Experimental insect		μg glycogen / gland	*P* value
Non-mated male	(7)	67.50 ± 4.98	
Mated male	(7)	43.79 ± 2.80	<0.001
Virigin female	(7)	65.75 ± 6.93	
Mated female before egg laying	(7)	61.25 ± 7.10	<0.001
Mated female after egg laying	(7)	38.31 ± 0.59	

The result indicates mean ± SE of seven experiments; number of insects used in indicated in parenthesis.

reproductive structures that are transferred may be the source of additional protein that occurred in the female accessory reproductive structures. It may be of particular interest to mention in this context that the male *Cecropia* moth transfers juvenile hormones (JH 1 & JH 2) to the female during copulation which are stored in the female ARGs (SHIRK *et al.*, 1980). The fate of JH in the female is not known since it has been shown that vitellogenin synthesis in this moth is not influenced by JH. The results presented in Table 3, however, indicate that the male silk moth injected with ^{14}C leucine when allowed to mate with the female, the accessory reproductive structures of the female showed accumulation of labelled protein. It is suggested that the proteins from the male are transferred during copulation in the silk moth *B. mori*. The role of these proteins, however, is unclear.

It is evident from the results presented in Table 2 that the protein content of the accessory reproductive structures of the female show substantial depletion of proteins after egg laying. Maximum depletion occurs in the ARG (66.11%) than bursa copulatrix (30.02%) and spermatheca (53.49%). In the silk moth *B. mori* the bursa copulatrix receives sperms during copulation and they are temporarily stored in the spermatheca. It appears that the increase of proteins in the gravid female and their depletion after egg laying may be due to the accumulation and utilization of transferred sperms for fertilization. Similarly, the decrease in the protein content of the female ARG may be due to their utilization for the egg coating (TAZIMA, 1978).

It is accepted that the glycogen serves as source of energy for various activities of insect (STEELE, 1982). The present study has revealed that the glycogen content of the male ARGs depleted significantly after mating. In the female, on the other hand the glycogen level is reduced substantially only after the egg laying. It seems that the glycogen is utilized as a sourcee of energy during mating in the case of male, whereas in the female it serves as source of energy during oviposition process.

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EFFECT OF *CATHARANTHUS* ALKALOIDS ON THE REPRODUCTIVE PERFORMANCE OF THE HOUSE FLY, *MUSCA DOMESTICA* L.

KUMUDA SUKUMAR

Pesticide Division, Regional Research Laboratory, Hyderabad, India

(Received 21 February 1986)

The total leaf alkaloids and root alkaloids of *Catharanthus roseus* induced significant sterility in males and females of the house fly, *Musca domestica*. The leaf alkaloid showed superior action when compared to root alkaloids. The root alkaloid, though inferior in its efficiency in inducing a higher degree of sterility, presented sex specificity by being more effective in females than males. When both sexes were treated, the alkaloids gave a cumulative effect. The plant deserves further attention since it shows commercial promise.

(Key words: Catharanthus alkaloids, *Musca domestica*, housefly, sterility)

INTRODUCTION

Natural products have always fascinated biologists because of their propensity to be used either as drugs or as insect control agents, and hence plant kingdom has been a fruitful hunting ground for bioactive compounds and many plants have emerged as important agents with significant bioactivity. ***Catharanthus roseus*** (Apocyanaceae) gained considerable reputation in recent years, since the discovery of anti-cancer properties of its alkaloids (NOBLE *et al.*, 1958). Research on anti-cancer agents has provided many leads to the discovery of insect reproductive inhibitors (BORKOVEC, 1962). The majority of known reproductive inhibitors, reduce or eliminate the reproductive capacity of the insects and function mostly by attacking the rapidly proliferating cellular systems of the reproductive organs. Although a direct relationship has not been established between the two biological activities (CHANG *et al.*, 1974) many anti-cancer agents have led to the development of an insect sterilant. The rapidly dividing cells of the insect reproductive system bear in some respect a close resemblance to those in a growing tumour and it is conceivable that a compound effective in one system could also affect the other. SUKUMAR & OSMANI (1981) reported that the leaf and root alkaloids of ***Catharanthus*** held promise as good sterilants against ***Dysdercus cingulatus***. The present work represents an extention of the study to ***Musca domestica*** to understand the generality of action of the alkaloids.

MATERIALS AND METHODS

Musca domestica was reared in the laboratory on a semisynthetic diet at 27 ± 3°C. The pupae were removed from the culture medium and kept for emergence. Flies less than 24 h old, were sexed and used for treatment.

The total leaf alkaloids were extracted from air-dried leaves with methanol in a soxhlet apparatus, methanol removed and the residue treated with chloroform. The chloroform soluble portion was treated with 1% HCl

and to the acid soluble portion 20% ammonia added (pH 9.0) (JOSHI & AMBAYE, 1968). The total alkaloid was obtained as a gift from the Central Institute of Medicinal and Aromatic Plants, Bangalore, India.

The alkaloids were dissolved in chloroform and graded concentrations made. The desired concentrations of alkaloid solutions were applied topically on the dorsal side of the flies at the rate of 1 μl/insect. The treated insects were caged with the untreated, unmated, freshly emerged flies of the opposite sex and the ratio of the male to the female was maintained at 20:15. In all the experiments, the insects were allowed to mate and after oviposition, the eggs were collected at random. Three hundred eggs in three batchs of hundred each were kept in culture medium separately, for viability studies. The maggots which hatched were counted and the sterility recorded. All the experiments were conducted in triplicate and continued for 20 days. Check insects received only solvent applications. The mean value of the triplicate testing was taken as the percentage observable sterility. This was corrected with natural sterility using Abbott's formula (ABBOTT, 1925).

RESULTS AND DISCUSSION

The results show that *Catharanthus* alkaloids can succesfully sterilize male and female of house flies. Table 1 shows the sterility data when the 1st batch of eggs in all the triplicate testing is taken into account. As in the case of *Dysdercus* the leaf alkaloid gave better sterilant action than the root alkaloid. SVOBODA (1963) and SVOBODA *et al.* (1975) reported that the activity of the plant was found entirely in its alkaloidal constituents and the leaf alkaloids were far more active than those of stems or roots.

The root alkaloid, though generally inferior to the leaf alkaloid in its efficiency, presented a sex specificity by inducing a higher degree of sterility in females than in males. When both sexes were treated the alkaloids gave a cumulative effect. But it was also observed that treatment of both sexes with lower doses resulted in a progressive recovery from the sterilant action since the subsequent batches presented lesser sterilant action and the viability of eggs increased with passage of time (Table 2). Although the recovery was quite remarkable at lower doses, at higher doses like 2% the recovery was negligible. Most of the doses like 3% to 4% alkaloids permanently sterilized the insect giving little scope for recovery. This indicates the possibility of sterilizing the insects permanently with higher doses and preventing them from recovering from the sterilized effect. Mating was not inhibited at any dose in either sex. The plant deserves deeper investigation as it shows potential promise for commercial exploitation.

TABLE 1. Sterility data in *Musca domestica* following topical treatment with *Catharanthus* alkaloids.

Total leaf alkaloid			Total root alkaloid		
% Dose	Percentage sterility		% Dose	Perccentage sterility	
	male	female		male	female
0.5	85.0	80	0.5	23	34
1.0	87.5	85	1.0	32	40
2.0	95.0	92	2.0	69	74
			3.0	76	88

TABLE 2. Recovery from sterilant action following topical treatment of *Catharanthus* alkaloids to *Musca domestica*.

% dose leaf alkaloid	% sterility in 3 batches of eggs		% dose root alkaloid	% sterility in 3 batches of eggs	
	treated male	treated female		treated male	treated female
0.5	I Batch = 85	I Batch = 80	0.5	I Batch = 23	I Batch = 34
	II Batch = 58	II Batch = 60		II Batch = 17	II Batch = 21
	III Batch = 49	III Batch = 43		III Batch = 12	III Batch = 7
1.0	I Batch = 87	I Batch = 85	1.0	I Batch = 32	I Batch = 40
	II Batch = 65	II Batch = 63		II Batch = 26	II Batch = 28
	III Batch = 57	III Batch = 52		III Batch = 14	III Batch = 19
2.0	I Batch = 95	I Batch = 92	2.0	I Batch = 69	I Batch = 74
	II Batch = 93	II Batch = 89		II Batch = 66	II Batch = 70
	III Batch = 90	III Batch = 87		III Batch = 60	III Batch = 65

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EFFECTIVENESS OF SPRAY FORMULATIONS AGAINST RICE LEAF FOLDER *CNAPHALOCROCIS MEDINALIS* GUENEE (LEPIDOPTERA : PYRALIDAE)*

MANGAL SAIN, N. V. KRISHNAIAH & M. B. KALODE

Directorate of Rice Research, Rajendranagar, Hyderabad, India 500 030

(Received 24 October 1985)

Fifteen insecticides available in the market were tested as high volume sprays while eight selected insecticides were evaluated as low volume sprays against leaf folder. Results revealed monocrotophos, chlorpyriphos, quinalphos and methyl parathion as effective insecticides.

(Key words: insecticides, spray formulations, leaf folder, rice, control with insecticide sprays)

INTRODUCTION

Earlier studies on chemical control of rice leaf folder, *Cnaphalocrocis medinalis* Guenee identified parathion or a mixture of toxaphene and DDT as foliar sprays (BALASUBRAMANIAN *et al.*, 1973); methyl parathion, phenthoate and endosulfan spray (DAS & NAIR, 1975); chlordimeform granules and spray (VELUSAMY *et al.*, 1978); carbaryl and methyl parathion (RAI & VIDYACHANDRA, 1979) as effective insecticides. Recently chlorpyriphos methyl and cartap (ENDO & MASUDA 1981) as well as thiocyclam hydrogen oxalate, isofenphos and carbosulfan (RAZVI *et al.*, 1983) were found to be better insecticides against this pest. Among the synthetic pyrethroids permethrin was particularly efficient in reducing leaf damage (SAROJA & RAJU, 1982b). Present studies were carried out to generate comprehensive information on the effectiveness of marketed spray formulations against leaf folder under field conditions.

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MATERIALS AND METHODS

Fifteen insecticide formulations available in the market were included in evaluation as high volume sprays (Table 1) while eight selected insecticides were evaluated as low volume sprays (Table 2). The insecticides effective against other rice insect pests were given preference for inclusion as low volume sprays while the number depended on the availability of experimental area.

In experiment with high volume sprays the plot size was 12 sq m with three replication while in low volume sprays the plot size was 44 sq m with 4 replications. All the insecticides were tested @ 0.5 kg ai/ha. In case of high volume spray the quantity of water required was 1000 litres/ha while in case of low volume spray 150 litres/ha was sufficient. Two sprays at 11 days interval were given in both the experiments. Observations on the leaf folder damaged leaves were taken one day before first spray application and twenty one days later. Only green damaged leaves were considered for estimation of damage. The leaves with 15 per cent or more damaged area were considered as damaged leaves. Five days after first spray 100 folded leaves from each plot were collected and dissected for number of larvae alive or dead and percentage mortality was calculated.

TABLE 1. Effectiveness of spray formulation against leaf folder as high volume sprays.

Insecticide		Formulation	ADL/Hill		% larval* mortality (70 DAT)
Common name	Trade name		BT (65 DAT)	AT (87 DAT)	
Quinalphos	Ekalux	25 EC	17.5	4.5	71 (84)
Thiometon	Ekatin	25 EC	17.8	6.2	15 (7)
Chlorpyriphos	Dursban	20 EC	16.6	5.8	59 (73)
Phosalone	Zolone	35 EC	17.6	6.3	21 (19)
Monocrotophos	Nuvacron	40 EC	18.6	6.2	78 (89)
Phosphamidon	Dimecron	40 EC	16.0	5.3	25 (18)
Fenthion	Lebaycid	100 EC	14.2	5.9	47 (54)
Endosulfan	Hildan	35 EC	14.9	6.4	44 (48)
Fenitrothion	Sumithion	50 EC	14.2	6.0	49 (57)
Methyl parathion	Metacid	50 EC	15.1	9.2	55 (67)
Malathion	Malathion	50 EC	15.4	12.2	35 (34)
Dichlorvos	Nuvan	100 EC	12 1	8.3	19 (16)
Carbaryl	Sevin	50 WP	13.6	8.9	19 (15)
Carbaryl	Svimol	40 LVC	14.4	9.8	31 (27)
Dimethoate	Rogor	30 EC	14 4	21.2	14 (6)
Untreated control			15.1	13.6	20 (12)
C D (0.05)			NS	2.3	21
C V (%)			20.1	16.3	33.4

* The values in parentheses are original values. NB: All the insecticides were applied @ 0.5 kg ai/ha. ADL = Average damaged leaves. BT = 1 day before first treatment; AT = 21 days after first treatment.

RESULTS AND DISCUSSION

Considering the data on both leaf damage and larval mortality from both the experiments (Tables 1 & 2), monocrotophos, chlorpyriphos, quinalphos and methyl parathion could be judged as better insecticides against rice leaf folder. Methyl parathion, monocrotophos, quinalphos (DAS & NAIR, 1975) and methyl parathion (RAI & VIDYACHANDRA, 1979) were reported to be effective against leaf folder which corroborate with the present findings. On the other hand, carbaryl (RAI & VIDYACHANDRA, 1979), fenitrothion, phosphamidon and dimethoate (DAS & NAIR, 1975) though reported to be effective insecticides did not exercise satisfactory control in the present investigation. Among the new spray formulations thiocyclam hydrogen oxalate, isofenphos and fenvalerate registered good degree of effectiveness (RAZVI *et al.*, 1983), while SAROJA & RAJU (1982a) reported bendiocarb and acephate as the most effective insecticides against this pest. Further it is evident that low volume (LV) spraying was equally effective to high volume spraying. Therefore, low volume spraying could be used

TABLE 2. Effectiveness of selected spray formulations against leaf folder as low volume sprays.

Insecticide		Formulation	ADL/Hill		% larval* mortality (62 DAT)
Common name	Trade name		BT (57 DAT)	AT (79 DAT)	
Quinalphos	Ekalux	25 EC	11.6	8.2	58 (66)
Thiometon	Ekatin	25 EC	10.3	7.3	38 (39)
Chlorpyriphos	Dursban	20 EC	9.6	6.5	81 (92)
Phosalone	Zolone	35 EC	9.2	10.3	42 (40)
Monocrotophos	Nuvacron	40 EC	10.3	6.1	75 (87)
Endosulfan	Hildan	35 EC	10.6	10.5	42 (46)
Methyl Parathion	Metacid	50 EC	11.7	6.7	81 (92)
Carbaryl	Sevimol	40 LVC	11.8	9.9	25 (18)
Untreated control			12.3	14.1	18 (13)
C D (0.05)			NS	2.15	32
C V (%)			14.8	16.7	42 8

* The value in parentheses are original values. NB : All the insecticides were applied @ 0.5 kg ai/ha. ADL = average damaged leaves; BT = 1 day before first treatment; AT = 21 days after first treatment.

to control leaf folder because of its obvious advantages of covering more area per unit time and less traversing per unit coverage. It was estimated that one hectare area could be covered within 8.3 hours by low volume spray as compared to 31.3 hours required for high volume spray.

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DAY BITING MOSQUITOES (DIPTERA: CULICIDAE) OF MANIPUR

K. B. RAJPUT[1] & T. K. SINGH

Department of Life Science, Manipur University, Manipur, India 795 003

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A total of twenty three spacies of mosquitoes with day biting habit belonging to six genera, viz *Anopheles, Aedes, Armigeres, Heizmania, Mansonia* and *Tripteroides* were recorded from the State. Monthly fluctuation in day biting density of day biters have been presented for Manipur Valley.

(Key words: day biting, mosquitoes, Manipur)

INTRODUCTION

The host-vector contact plays a pivotal role in the dynamics and probability of disease transmission by the vector species. The probability of infestation, and intensity increases with the increasing number of biting by the vector species. This probability of infestation definitely increases for the vector species which use to bite during day also. In diurnal species, the availability of host during day in the area also intensifies the probability of host-vector contact. In the forested or industrial dumping areas these day biters bacome very much of an annoyance to human beings.

In view of above, the present study was conducted during October, 1983 to September 1984 to know the day biting mosquitoes of the State. During the study regular fortnightly sampling from valley and erratic survey with emphasis on day biting species was done from some hilly regions of the State.

1 Present address: Regional Tasar Research Station, Mantripokhari, Imphal, Manipur, India 795 002.

MATERIALS AND METHODS

Fortnightly human bait collections during day for one hour in each fortnight in the Oak (*Qurcus serrata* Thunb.) plantation at Regional Tasar Research Station, Imphal (Manipur) was maintained for one year. For the bait collection self bait with aspirator tube collection technique was applied (W H O, 1975). Some erratic samples were also taken from the hilly region of the State from varied topographic divisions. The mosquitoes collected were killed with ether and kept seperately with date and locality record for identification. The collected specimens were identified with the key of BARRAUD (1934), CHRISTOPHERS (1933), Catalog of the KNIGHT & STONE (1977), and RAO (1984). The specimens were preserved and includes in the collection of Life Science Department, manipur University Manipur (India).

RESULTS

A total of 365 mosquitoes belonging to 6 genera and 23 species, were collected during biting in day. Out of these 9 species, viz: *Anopheles barbirostris, Aedes albopictus, Ae. caecus, Ae. vexens, Ae. andamanensis, Ae. lineatopennis, Armigeres subalbatus, Mansonia indiana* and *M. uniformis* were collected from valley of the State and some 18 species (Table 1)

TABLE 1. Day biting mosquitoes from hilly region of Manipur.

S. No.	Species	No. of females collected	Locality	*Topography
1	*Anopheles barbirostris* Vanderwulp, 1884.	01	Geljang (850m)**1, 27.xii.84.	1
2	*Aedes albopictus* (Skuse), 1894	09	Moltam (850m) 1, 1.xi.84	1
			Moreh (150m) 2, 18.xii.84	2
			Nungba (759m) 8.x.84	3
3	*Ae. mediopuctatus* Theobald, 1905	07	Nungba, 6, 8.x.84	3
			Tamenglong (12 room) 1, 8.ix.'84	4
4	*Ae. formosensis* Yamada, 1921	02	Nungba, 2, 8.x.84	3
5	*Ae. niveus* group	04	Nungba, 4, 8.x.84	3
6	*Ae. (Finlaya)* sp.?	01	Moltam, 1, 1.xi.84	1
7	*Armigeres subalbatus*	21	Jiribam (850M) 15, 7.x.84	5
			Moreh 6, 18.viii.84	2
8	*Ar. theobaldi* Barraud, 1933	05	Moreh, 5, 18.viii.84	2
9	*Ar. dentatus* Barraud, 1927	05	Nungba, 5, 8.x.84	3
10	*Ar. digitatus* Edwards, 1914	16	Nungba, 16, 8.x.84	3
11	*Ar. flavus* (Leicester) 1908	01	Nungba, 1, 8.x.84	3
12	*Ar. inchoatus* Barraud, 1927	03	Nungba, 3, 8.x.84	3
13	*Ar. longipalpis* (Leicester) 1904	05	Nungba, 3, 8.x.84	3
			Tamenglong 2, 8.x.84	4
14	*Ar. magnus* (Theobald) 1908	02	Nungba, 2, 8.x.54	3
15	*Ar. omissus* Edwards, 1914	34	Nungba. 34, 8.x.84	3
16	*Heizmania complex* (Theobald) 1910	12	Moreh, 6, 18.viii.84	2
			Nungba, 6, 8.x.84	3
17	*Mansonia uniformis* (Theobald) 1901	01	Moltam, 1, 1.xi.84	1
18	*Tripteroides powelli* var *indicus* Barraud, 1929.	01	Nungba, 1, 8.x.84	3
		130		

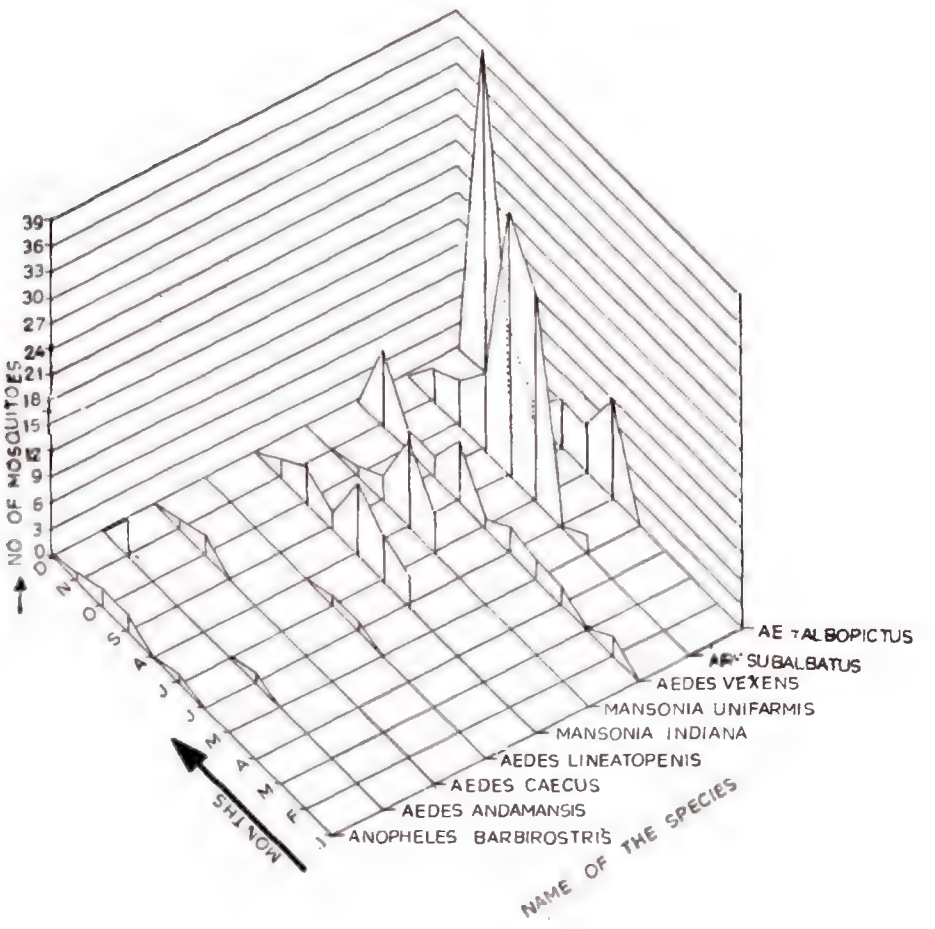
* 1. Hilly region, with prevalent oak forest. *(Qurcus serrata* and *Q. dealbata).*
2. Hilly region with dense tree forest. 3. Hilly region with predominent bamoo bushes.
4. Hilergil yon with mixed type of forest. 3. Plain region, with domestic habitations.
** M. S. L. Altitude of the place.

were collected from hilly region. *Anopheles barbirostris*, *Aedes albopictus.*, *Armigeres subalbatus* and *Mansonia uniformis* were common from both hilly and valley region. The most important day biters of the State may be pointed out as *Armigeres subalbatus*, *Aedes albopictus*, *Armigeres omissus*, *Aedes vexens*, *Mansonia indiana*, *M. uniformis*, *Heizmania complex* and *Aedes mediopunctatus*.

The annoyance of day biters in valley initiates wef June to November, with the peaks in July—August and November (Fig. 1). No biting were recorded during the months of December and January probably due to being coldest months for the State.

Erratic surveys from different parts of the hilly region of the state reveals a very rich day biting fauna in the hilly region. During survey a number of day biters were collected especialy from predominent bamboo areas. It is noteworthy to mention that a single half hour self bait collection from Nungba forest yielded 13 species. In the forest, most of the day biters use to breed in bamboo cuts.

FIG-I
DAY BITING MOSQUITOES OF MANIPUR VALLEY



DISCUSSION

Recorded twenty three day biting mosquito species from the state belong to six genera viz., *Anopheles*, *Aedes*, *Armigeres*, *Heizmania*, *Mansonia* and *Tripteroides*. The maximum number of day biting species were recorded from genera *Aedes* and *Armigeres* (9 species each) followed by *Mansonia*, (2 species) *Anopheles*, *Heizmania* and *Tripteroides* (1 species each).

Among anophelines *Anopheles barbirostris* which is a reported secondary vector of human filariasis in India (RAGHAVAN, 1969), and found to harbour Japanese encephalitis virus from West Bengal (NIV. Document, 1979), was recorded to bite during day also in the jungles of the State. The similar day biting observations were also reported earlier by CHRISTOPHERS (1933), from Andaman Island and by KHIN-MAUNG-KYI (1977), from adjoining Burma.

Genus *Aedes* which contains 9 day-biting mosquito species represents *Aedes albopictus*, *Ae. vexens* (in valley) and *Ae. mediopunctatus* (in bamboo predominent areas) serves as severe day biters, while other species were not so annoying. Except the predominent species *Aedes albopictus* recorded from both hilly and valley regions, the two regions represent its seperate day biting aedine fauna. *Aedes vexens*, *Ae. caecus*, *Ae. andamanensis* and *Ae. lineatopennis* were recorded from valley while *Ae. mediopunctatus*, *Ae. formosensis*, *Ae. niveus* group and *Ae. (Finlaya)* sp. were recorded from hilly region of the State. *Aedes albopictus* a reported vector of Dengue fever in Singapore (CHAN *et al.*, 1964), vector of *Dinofilaria immitis* in Nagasaki (Japan) and Thailand (HORSFALL, 1972), and capable of transmitting chickungunya virus in laboratory trials (RAO *et al.* 1964), maintains its second position in the State as day biter.

Genus *Armigeres* which includes the most vicious biter of the State, *Armigeres subalbatus* is prevalent in valley and hilly regions of the State. In valley *Ar. subalbatus* which is mainly domestic discarded container breeder, maintains its first position as day biter while in the hilly areas with predominent bamboo bushes *Ar. omissus* (bamboo breeder) ranks first. The other bamboo breading members of the group viz: *Ar. dentatus*, *Ar. digitatus*, *Ar. flavus*, *Ar. inchoatus*, *Ar. longipalpis* and *Ar. magnus* shares the day biting activity in the hilly region.

Genus *Heizmania* represented by *Heizmania complex* was collected during day biting from hilly region with predominent bamboo bushes. The day biting behaviour of the species was unknown from the work presented by BARRAUD (1934).

Mansonia uniformis and *M. indina* which are the important filaria vectors of India (RAGHAVAN, *Loc. Cit.)* were recorded biting during day also from the state.

Under genus *Tripteroides*, *Tridteroides powelli* var. *indicus* was collected during day biting from bamboo forest. Observation "The species is diurnal but not abundant or troublesome' (BARRAUD, 1934) was also found correct during the present study

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GROWTH PATTERN OF *CORCYRA CEPHALONICA* PUPA AND EFFECT OF DIFLUBENZURON ON PUPAL WEIGHT[1]

M. SRIRAMULU[2] & K. N. MEHROTRA

Division of Entomology, Indian Agricultural Research Institute, New Delhi 110 012

(Received 31 July 1985)

Growth pattern in normal and diflubenzuron treated pupa of *Corcyra cephalonica* was studied. The pupa continuously lost weight. Normal pupa lost weight by 0.59 mg/day. The loss in weight in diflubenzuron treated pupa was 0.75 mg/day/pupa.

(Key words: growth, diflubenzuron, histolysis, xenobiotic, metabolism)

INTRODUCTION

The quantitative measurement of growth is based usually on weight. Although growth with respect to increase in weight in the larval stage has been reported (HUSSAIN & MATHUR, 1944; DAVEY, 1955; CHURCH & ROBERTSON, 1966; MEHROTRA *et al.*, 1972; MEISNER *et al.*, 1976; SUNDARAMURTHY, 1977; WARTHEN & UEBEL, 1980), there is a dearth of information on this aspect in pupal stage, as far as pupal growth is concerned.

AGRELL (1949) observed mutual change in weight of thorax and abdomen during pupal development of *Calliphora erythrocephala* mainly due to histolysis of larval fat body in the abdomen and histogenesis of imaginal organs in the insect. No change in weight during pupal development was reported in *Tribolium confusum* (CHAUDARY & LEMONDE, 1966) and *Drosophila melanogaster* (CHURCH & ROBERTSON 1966). In contrast to this, decrease in weight during pupal development has been reported in *Culex pipiens* (CHEN, 1958; ROZEBOOM & TWOHY, 1958), *Aedes aegypti* (LANG *et al.*, 1965) and in diapausing pupae of *Papilio zelicron* (SIMS, 1983). Moulting is primarily a mechanism of growth. VAN DAALEN *et al.* (1972) reported that benzoylphenylureas affect the moulting in insects. The effect of diflubenzuron on the weight of larvae was observed in *Musca domestica* (ISHAAYA & CASIDA, 1974) and *Spodoptera litura* (SUNDARAMURTHY, 1977). These studies revealed that diflubenzuron decreased the rate of increase of weight in larval development. Though loss in weight during development in insecticide treated larvae was reported in literature, so far such data on pupal development is not available,

Therefore, the present study is concerned with the pupal growth pattern of *C. cephalonica* and the effect of diflubenzuron on it.

MATERIALS AND METHODS

The pupae of *Corcyra cephalonica* Stainton (Pyralidae : Lepidoptera) were obtained from a laboratory colony maintained on broken *Sorghum bicolor* (L.) grains. Technical grade diflubenzuron was a gift from Dr. A.B. BORKOVEC, Insect Chemosterilants Laboratory, United States

[1] Part of the thesis submitted to P. G. School, I. A. R. I., New Delhi for award of Ph. D.

[2] Department of Entomology, College of Agril., R'nagar, Hyderabad

Department of Agriculture, Beltsville, Maryland, U. S. A.

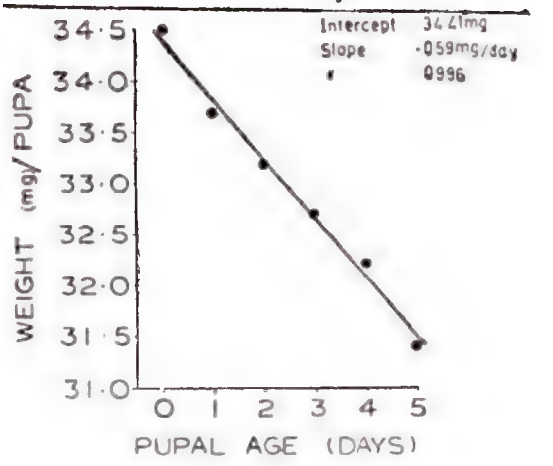
To study the growth pattern, three replications of 20 pupae each were weighed at 24 h interval from the time of pupa formation till the emergence of adults. To study the effect of diflubenzuron treatment on pupal weight, 30 pupae were injected with 0.1 µg diflubenzuron per fresh pupa (0 day) and the pupae kept as control were injected with solvent only (dimethylformamide : methyl alcohol at 2:3 ratio) and were weighed at 24 h intervals throughout the pupal period. The pupae were injected with the help of an electrically operated micro-applicator (Model M 1025, Instrumentation Specialities Company, U. S. A.). The pupae of *C. cephalonica* were weighed with the help of a single pan balance type K - 15, K - Roy, Varanasi, India.

RESULTS

Weight of pupa of C. cephalonica during development:

The data presented in Table 1 indicated that the insect continuously lost weight. The weight decreased from 34.5 mg to 31.4 mg during pupal development. When the data were subjected to linear regression analysis by the least squares method, it gave a straight line (Fig. 1) with the regession equation $Y = 34.41 - 0.59\,X$, where Y was the weight of pupa in mg and X the age of pupa. From the equation it would be seen that the pupa loses weight at the rate of 0.59 mg/day.

Fig 1.



Effect of diflubenzuron on pupal weight during development:

From the data presented in the Table 2, it would be seen that in the solvent

TABLE 1. Weight of pupa of *C. cephalonica* during development.

Pupale age (days)	weight of 20 pupae mg			mean weight mg/pupa
	R_1	R_2	R_3	
0	693	696	679	34.5
1	681	676	667	33.7
2	672	662	660	33.2
3	662	647	654	32.7
4	650	634	649	32.2
5	637	618	629	31.4

R = Replication

For obtaining insects immediately on pupation the following method originally devised by de Wilde *et al.*, (1968) was used. Larvae were released in petridishes containing teflon tubes. The larvae entered the tubes and pupated. These tubes containing light brown pupae were picked out and these were classified as 0 - day pupae.

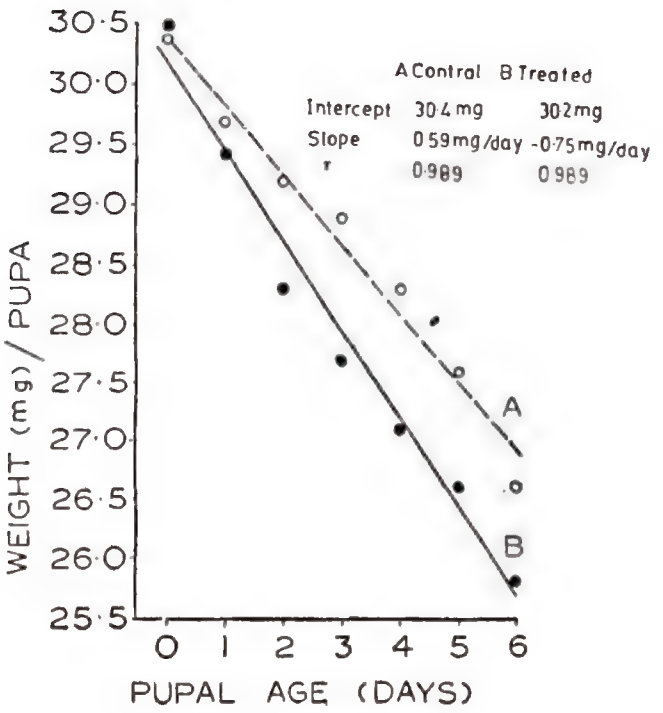


TABLE 2. Effect of diflubenzuron on pupal weight of *C. cephalonica* during development.

Pupal age (days)	mean weight mg/pupa	
	control	treated
0	30.4	30.5
1	29.7	29.4
2	29.2	28.3
3	28.9	27.7
4	28.3	27.1
5	27.6	26.6
6	26.6	25.8

Each value is the mean 30 pupae.

Diflubenzuron (0.1 μg/pupa) was injected into 0-day old pupa as a solution in 0.25 μl of a mixture of dimethyl formamide and methanol (2:3 v/v). The controls were injected with solvent only.

treated control, weight decreased from 30.4 mg to 26.6 mg during pupal development period while it decreased from 30.5 to 25.8 mg in diflubenzuron treated pupa. These data, when subjected to linear regression by least squares method, gave a straight line (Fig. 2) with the regression equation $Y = 30.4 - 0.59\ X$ for control and $Y = 30.2 - 75\ X$ for diflubenzuron treated pupae. From the regression equations it could be seen that diflubenzuron treated pupa lost weight at the rate of 0.75 mg / day when compared to 0.59 mg/day in control pupa. The slope (–0.59 mg/day) of the solvent injected control pupa is similar to the slope of the normal pupa of the earlier experiment.

DISCUSSION

Although the growth pattern of larval stages have been extensively studied (HUSSAIN & MATHUR, 1944; DAVEY, 1955; CHURCH & ROBERTSON, 1966; MEHROTRA *et al.*, 1972; WARTHEN & UEBEL, 1980), it has been poorly investigated in pupal stage. In *C. cephalonica* the pupa lost weight by 0.59 mg/day. Loss in weight during pupal development has been observed in *Culex pipiens* (CHEN, 1958; ROZEBOOM & TWOHY, 1958), *Aedes aegypti* (LANG *et al.*, 1965). Absence of such loss of weight has been reported in *Calliphora erythrocephala* (AGRELL, 1949), *Tribolium confusum* (CHAUDHARY & LEMONDE, 1966) and *Drosophila melanogaster* (CHURCH & ROBERTSON, 1966). The major events involved in the reorganisation during metamorphosis in insects are the histolysis of the larval tissues and building up of the imaginal structures (CHEN, 1971). The nutrient reserves are the major energy source during metamorphosis. STRAUSS (1911) reported that the worker bee utilised 95 per cent of glycogen and 75 per cent of fat during the pupal period, CHEN (1958) reported a gradual decrease in free amino acids like alanine, leucine and β-alanine during pupal development of *Culex pipiens*. LANG *et al.*, (1965) reported loss of water during pupal development of *Aedes aegypti*. Loss of water and utilisation of energy reserve for various metabolic processess during pupal development might be responsible for gradual decreases in pupal weight in *C. cephalonica*.

Diflubenzuron treatment increased the rate of loss in weight throughout the pupal period in *C. cephalonica* pupa. The loss in weight in treated pupa was 0.75 mg/day/pupa compared to 0.59 mg/day/pupa in normal insects. Although there are no reports showing the loss of weight as a result of diflubenzuron or any other phenyl urea derivative in pupal stage, reduction in rate of increase in weight during larval development has been observed in other insects (ISHAAYA & CASIDA, 1974; SUNDARAMURTHY, 1977). This loss in weight was most probably due to a higher rate of metabolism especially respiratory, induced by the insecticide. The injected diflubenzuron is a xenobiotic and is to be metabolized and conjugated (CHANG, 1978; IVIE & WRIGHT, 1978) before it can be eliminated from the system. As the pupal stage in the holometabolousinsects is a closed system, diflubenzuron must be detoxified and stored in such a way that it does not affect the normal development. This detoxification mechanism also may increase metabolic activity. Enhanced metabolic activity would lead to a greater depletion of energy reserve probably resulting in more loss in pupal weight.

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THE METABOLISM AND EXCRETION OF ^{14}C-LABELLED DIELDRIN IN RESISTANT AND SUSCEPTIBLE *TRIBOLIUM CASTANEUM* (HERBST)

A. S. UDEAAN & R. L. KALRA

Department of Entomology, Punjab Agricultural University, Ludhiana-4, India

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The metabolism and excretion of ^{14}C-dieldrin in the resistant and susceptible strains of *Tribolium castaneum* was studied. Adults of resistant strain were found to metabolize dieldrin to about six metabolites, two of which were identified as trans-aldrindiol and 9-hydroxy dieldrin. The metabolism of dieldrin in the resistant strain was more pronounced than in the susceptible strain. The high level of trans aldrindiol found in the resistant strain suggests that its formation was a detoxication reaction. The results also indicate the high rate of excretion of this insecticide by the adults of the resistant strain.

(Key words: metabolism, excretion, dieldrin, *Tribolium castaneum)*

INTRODUCTION

Tribolium castaneum (Herbst) has been reported to be resistant to lindane in various countries of the world, including India (CHAMP & DYTE, 1976; KALRA *et al* , 1975). Like other insect species, the lindane-resistant *T. castaneum* showed cross resistance to dieldrin (BHATIA & PRADHAN, 1972; BARWAL & KALRA, 1982). However, there does not seem to be any information available on the mechanisms of dieldrin-resistance in this species. Hence, the present investigations were carried out to elucidate the role of metabolism and excretion of dieldrin as possible mechanisms of resistance in *T. castaneum*.

MATERIALS AND METHODS

^{14}C-Dieldrin (85 mci/mmol) was obtained from Radiochemical Centre, Amersham (U K). Its purity was checked before use by thin layer chromatography system described below. Some of the non-radioactive metabolites of dieldrin namely, trans aldrindiol, 9-hydroxy dieldrin, photodieldrin and 4,5-aldrin-dicarboxylic dimethyl ester were supplied by the Institute of Ecological Chemistry, Munich, W. Germany. The X-ray plates for raidoautography were obtained from Hindustan Photo Film Manufacturing Co., India. Audlts of Lindane resistant (R) and susceptible strain (S) of *T. castaneum* used in this study were from stock cultures maintained in this department; the detail regarding these were earlier given by BARWAL & Kalra (1982).

Metabolism: Batches of 100 aduts of both susceptible and resistant strains of *T. castaneum* were treated topically with 1μl acetone solution of ^{14}C-dieldrin at the dose of 0.1μg per insect. The treated insects were held without food for 48 hours, after which those were homogenized along with their faeces in 10 ml of acetonitrile. The supernatant was separated after centrifugation of the homogenate. The residual material was rehomogenized twice with acetonitrile. The supernatant from the three spins were combined and then centrifuged at 1500 rpm for 10 minutes. The resultant supernatant was evaporated to near dryness under a stream of nitrogen. The residue was taken in 10 ml of petroleum ether and cleaned

up by colum chromatography, using 'Florisil' as adsorbent (KLEIN *et al.*, 1968). Elution was carried out first with 100 ml of 15 per cent ethyl ether and 0.3 per cent acetone in petroleum ether and then with 150 ml of acetone. These eluates were concentrated to small volumes with stream of nitrogen and then spotted on thin layer chromatoplates coated with silica gel G. The TLC plates were developed in the solvent system consisting of benezene-ethyl acetate (3:1, v/v) and exposed to X-ray films for 15 days.

The silica gel areas corresponding to the spots on the X-ray film were separately scrapped and eluted in 10 ml acetone The silica gel was removed by centrifugation and the supernatant was transferrsd to the scintillation vial. The vial was kept in an oven at 50°C to evaporate acetone. To this was added 10 ml of the scintillation cocktail prepared by dissolving 3 g of PPO and 100 mg of POPOP in 1 litre of toluene. This was shaken well and kept overnight at room temperature. The counts were recorded in Packard Liquid Scintillation Spectrometer Model 4430 in which the counts were corrected automatically for background.

The method of SINGH & THORNHILL (1980 a) was also used for the isolation and characterisation of metabolites of ^{14}C-dieldrin formed by adults of the resistant strain. For this purpose, 550 adults of *T. castaneum* were treated topically with ^{14}C-dieldrin at 0.1 μg/insect At the end of 48 hours, the insects were extracted. The purified extract was spotted on TLC plates and run using four different solvent systems, i.e. acetone-hexane (1:3, v/v), chloroform-ethatol (9:1, v/v), ether-hexane (1:1, v/v) and benzene-ethylacetate (3:1, v/v). The plates after development were exposed to X-ray films as described above for location of the spots. Authentic samples of metabolites of dieldrin were developed in similar solvent systems and detected by silver nitrate method (MATTHEWS & MATSUMURA, 1969).

Excretion :

Groups of 20 aduls of S- and R- strains were treated topically with 1 μl acetone solution of ^{14}C-dieldrin. Treated insects were kept in glass beakers and were not given any food. Groups of 20 insects were transferred to Potters' Elvejhem homogeniser at 4, 8, 24 and 48 hours after the treatment. These were rinsed twice with 10 ml of acetone to remove the unabsorbed insecticide. The insects were then homogenised with 10 ml of acetone for 2 minutes and the homogenate was centrifuged at 1500 g for 2 mirutes. The residue was rehomogenised twice using 10 ml of acetone each time. The supernatants from all the three spins were then combined to give the internal (absrobed) insecticide. Faeces were collected from the glass beakers used to hold the insects with the help of camel hair brush and were then extracted following the method described for extraction of the absorbed insecticide. The holding beakers were rinsed with 10 ml of acetone to know the extent of removal of insecticide from insects as a result of abrasion. The extracts, thus oblained, were transferred to scintillation vials. The vials were kept in an oven at 50°C till the complete evaporation of solvoent. To each of the vial, 10 ml of scintillation cocktail was added. These were shaken well and kept overnight at room temperature before the counts were recorded.

RESULTS AND DISCUSSION

Adults of resistant strain of *T. castaneum* were found to form seven to eight metabolites of ^{14}C-dieldrin, of which two were identified as trans-aldrindiol and 9-hydroxy dieldrin (Fig. 1). Likewise KORTE & ARENT (1965) isolated six metabolites of dieldrin from the urine of rabbits after its oral administration. NELSON & MATSUMURA (1973) reported that *Blattella germanica* metabolised dieldrin into two mono-hydroxy dieldrins and trans-aldrindiol. Five metabolites of dieldrin were detected in *Blaberus discoidalis* (SINGH & THORNHILL, 1980 a), while seven were found in blowfly, *Calliphora erythrocephala* (SINGH & THORNHILL, 1980 b).

The resistant strain of *T castaenum* was found to metabolize 22.5 per cent of the applied ^{14}C-dieldrin in 48 hours as compared to only 1.6 per cent by the susceptible strain (Table 1). Transaldrindiol was found to be the major metabolite in both the strains, but its amount

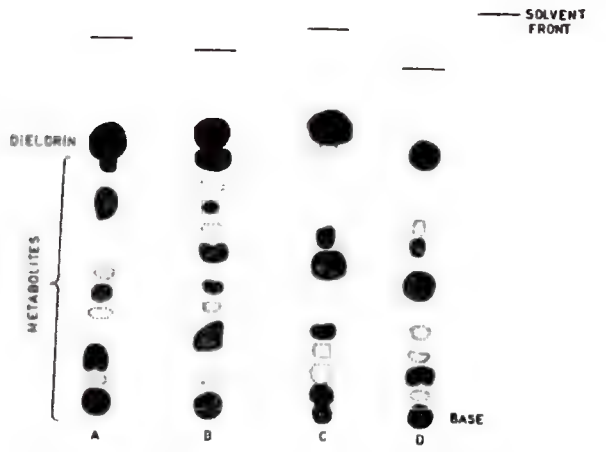

Fig. 1. Representatation of autoradiograms showing thin-layer chromatographic separation of ^{14}C-dieldrin and its metabolites extracted from resistant *T. castaneum* using different solvent systems (A) acetone-hexane 1:3 v/v (B) chloroform-ethanol, 9 : 1 v/v (C) Ether-hexane, 1:1 v/v (D) benzene-ethylacetate, 3:1 v/v. Soild spots- major metabolites; dotted spots- minor metabolites.

was significantly more in the R- strain than in the S- strain. Earlier, OONNITHAN & MISCUS (1964) reported that ^{14}C-dieldrin was metabolized by dieldrin-resistant *Culex pipiens quinquefasciatus* to aldrindiol. On the other hand PERRY *et al.* (1964) reported that ^{14}C-dieldrin was neither metabolized nor excreted by any of the susceptible and dieldrin-resistant houseflies *Musca domestica* Later SELLERS & GUTHRIE (1972) reported the presence of polar metabolites of dieldrin in the resistant strains of houseflies at extended periods after treatment.

Dieldrin has been reported to stimulate synapses and sensory receptors and to induce the formation of multiple discharges after a long latency. However, trans-aldrindiol was found to exert this effect more quickly (WANG *et al* ., 1971; VANDEN BERCKEN & NARAHASHI, 1974; NARAHASHI, 1976). It was, therefore, considered that trans-aldrindiol was an active form of dieldrin. According to BROOKS (1980), the contribution of this metabolite to dieldrin action, however, remains conjectural. The hydroxylation of dieldrin to cis- and trans-aldrindiol has been reported to be mediated by the mixed-function oxidases (NELSON & MATSUMURA, 1973; MATTHEWS & MC KINNEY, 1974). In view of the fact that the inhibitor of mixed-function oxidases, sesamex exhibited small synergistic effect on dieldrin, the diol formation does not seem to be an activation reaction. Further, the amount of trans-aldrindiol found in the nerve cord as a result of *in situ* formation was too insufficient to account for toxicity since larger amounts of it entered the nervous system following topical application or injection without any poisoning effect (BROOKS, 1977: SCHROEDER *et al.*, 1977;

TABLE 1. Relative amounts of ^{14}C dieldrin and its various metabolites in the resistant and susceptible strains of *T. castaneum*.

	Per cent radioactivity	
	resistant strain	susceptible strain
	mean ± S D	mean ± S D
Dieldrin	77.5* ± 2.1	98.4 ± 0.2
Metabolites		
M_1	0.5 ± 0.1	0.3 ± 0.04
M_2 (9-hydroxy dieldrin)	2.6 ± 1.3	0.2 ± 0.0
M_3	0.6 ± 0.07	N D
M_4 (transaldrindiol)	15.1 ± 0.7	0.6 ± 0.07
M_5	1.1 ± 0.3	0.3 ± 0.04
M_6	1.7 ± 0.6	0.2 ± 0.03

N D—not detected; S D—standard deviation; * Mean of two replications.

TABLE 2. Recovery of dieldrin (p moles) in external rinses, internal fraction and excreta of S- and R- strains of *Tribolium castaneum* over different time intervals.

Fraction	p moles of ^{14}C-compounds/20 insects at interval of							
	4 hr		8 hr		24 hr		48 hr	
	S	R	S	R	S	R	S	R
External	82.45*± 18.40	117.15± 6.28	50.71± 10 36	36 24± 3.86	23 45± 3.15	16 66± 3 33	26.09± 11.26	9.85± 3.40
Internal	293.28± 41.09	137.51± 31.33	303.35± 12.69	162 49± 18.49	363.66± 49 45	73.60± 9.07	270.61± 56 67	33 78± 16.54
Faeces	5.76± 1.41	18.73± 4.05	8 37± 0 68	37.21± 2.43	20.72± 4.66	135.81± 1.98	31.43± 8.91	182.09± 7.76
Container wash	8.24± 1.8	17 03± 0.57	8.43± 1.01	14.27± 1.37	11.70± 1.16	21.72± 1.83	16 02± 5.02	21 10± 1 42

*Mean of three replications. ± standard deviation; S- Susceptible strain; R- Resistant strain.

SINGH, 1980). The high amount of trans-aldrindiol found in the R- strain of *T. castaneum* during the course of the present studies further support that the diol formation is a detoxication rather than an activation reaction.

The radioactivity found in the faeces of resistant strain was much higher than that in the faeces of the susceptible strain (Table 2), thereby suggesting the excretion of insecticide as a possible mechanism of dieldrin-resistance in *T. castaneum*. The

parent dieldrin was also detected in the excreta by gas-liquid chromatography. Earlier ROWLANDS *et al.* (1973) reported that the adults of resistant strain of *T. castaneum* excreted significantly higher amount of intact lindane than their susceptible counterparts. Resistant strains of houseflies have also been found to excrete more of ^{14}C-dieldrin than the susceptible strain (WINTERINGHAN & HARRISON, 1959; SELLERS & GUTHRIE, 1972).

The internal level of ^{14}C-compounds in susceptible adults was more than in the resistant adults. However, this cannot be attributed to decreased penetration of the insecticide as the difference between the strains in the external/container wash was not much.

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HOW MANY LARVAL INSTARS ARE THERE IN *OPISINA ARENOSELLA*?

P. B. SANTHOSH BABU & V. K. K. PRABHU

Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581

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Detailed laboratory studies at ambient conditions of 23—32°C and 75—90% RH (in Trivandrum, Kerala) at 12 : 12 photoperiod show that the insect *O. arenosella* has eight larval instars; the ratio of head capsule width of successive instars is more or less constant, ranging between 1.2 and 1.7; the graph showing log head capsule width and instar is a straight line.

(Key words: Opisina arenosella (Nephantis serinopa), coconut leaf eating (black headed) caterpillar, larval instars)

INTRODUCTION

Opisina arenosella Wlk. the black headed caterpillar of the coconut palm, has been reported to possess 5 larval instars (LEVER, 1969; NIRULA, 1956); six instars (NIRULA *et al.*, 1951 as cited by RAMACHANDRAN *et al*, in their review, 1979) or even seven (ANTONY, 1962). However, more surprisingly, in our culture, we noted eight larval instars (unpublished observations). It is not uncommon for an insect species, especially belonging to Lepidoptera, to show variable number of instars in the life history. These supernumerary larval instars are induced by such factors as cooling (CYMBOROWSKI & BOGUS, 1976), chilling (PIPA, 1976), starvation (BHASKARAN & JONES, 1980; NIJHOUT, 1975) and injury (KRISHNAKUMARAN, 1972). Earlier workers on *Opisina* did not give any details of the method employed for their studies which were apparently rather casual laboratory observations. So it was thought that one or more of the above factors could be responsible for the discrepancy in the number of larval instars observed. It was found that this problem has not been carefully studied so far and so we conducted a detailed and careful study of the early life history (egg to pupa) of this insect in our laboratory and our findings are reported here.

MATERIALS AND METHODS

The stock culture of the insect was maintained in the laboratory (on natural food) at ambient temperature 23—32°C, 75—90% RH and 12:12 LD period approximately. The newly hatched 1st instar caterpillars were removed from this colony and their moult was followed and the number of instars counted. The observations were made for the duration of one year covering the peak period (from March to July) and lean period (from August to February). During this period of study, 7 batches each containing 8–10 larvae were examined. The larvae hatched from eggs were collected immediately and allowed to feed on 6 cm long pieces of matured coconut leaves. The leaves containing larvae were kept in clean specimen tubes (8 × 2 cm). Each specimen tube contained one larva. The specimen tubes were covered with white cloth, thus preventing escape of the larvae. The leaves were changed every day. The measurements were taken 10 h after ecdysis. The ecdysial day was designated as day-1. The

width of head capsule was measured under a stereomicorscope with an ocular micrometer.

RESULTS AND DISCUSSION

Of the total of all observations, it was consistently found that in all individuals there were eight larval instars. The measurements of head casule width as well as length and breadth of the instar and its duration are shown in Table 1, which also indicate the ratio of the head capsule width of successive instars. Fig. 1

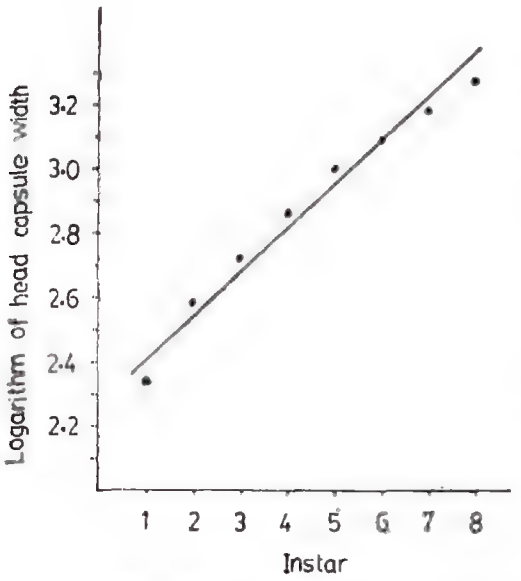

Fig. 1. Relationship between log head capsule width and instar in *Opisina arenosella*.

shows the relationship between larval stage and the log of head capsule width, which is almost a straight line, and the ratio of increase in head capsule width is 1.4 for most of the instars, except for the first to second instar, where it is 1.7 and during final three instars it is 1.2, 1.3 & 1.3. During the penultimate stages there is a tendency for decrease in the ratio from 1.4. On the whole, Dyers rule is found to hold good as shown in Table and in Fig. 1. It is known that when there are supernumerary larvae due to insufficient nutrition, the ratio tends to be lower (SEAMENS & WOODRUFF, 1939). There are also other factors which could induce supernumerary instars as chilling (PIPA, 1976; NIJHOUT, 1975), injury (KRISHNAKUMARAN, 1972) and starvation (BHASKARAN & JONES, 1980). Though variable number of instars have been repored for this species by different workers viz: five (LEVER, 1969; NIRULA 1956), six (NIRULA *et al.*, 1951 as reported by RAMACHANDRAN *et al.*, 1979) or even seven (ANTONY, 1962), it my be noted that the above authors do not appear to have made any detailed studies on this problem and hence the discrepancy. For example, NIRULA *et al.* (1951) as reported by RAMACHANDRAN *et al.* (1979) recorded six larval instars for this insect, though according to NIRULA *et al.* themselves (NIRULA *et al.*, 1951) and NIRULA (1956) it had only five larval instars and apparently RAMACHANDRAN *et al.* (1979) quoted NIRULA *et al.* (1951) erroneously. First instar of NIRULA (1956) and NIRULA *et al.* (1951) appears to consist actually of first and second instar of the present studies based on body length given by them (NIRULA has not given head capsule width); his second instar consists of the third and fourth instars; third instar corresponding to present fifth instar; fourth instar corresponding to sixth instar; his fifth instar corresponds to the present seventh and eighth instars. Apparently, Nirula's first, second and fifth instars are heterogeneous population made up of two larval instars each.

As mentioned previously many extraneous evironmental and nutritive factors affect the number of instars in the larval period. It may be noted that all the

TABLE 1. Duration of larval instars, head capsule width and body length of *Opisina arenosella* larva on coconut leaves during development.

Instar	number of insects used	duration (days)	head capsule width (mm)	*RW	larval body length (mm)	
					1st day of instar	last day of instar
I	78	3.33 ± 0.47	0.22 ± 0.02	——	1.54 ± 0.10	2.69 ± 0.24
II	66	3.50 ± 0.50	0.38 ± 0.03	1.7	2.77 ± 0.30	3.78 ± 0.38
III	61	3.77 ± 0.46	0.52 ± 0.02	1.4	3.93 ± 0.39	5.24 ± 0.37
IV	56	4.43 ± 0.49	0.72 ± 0.02	1.4	5.46 ± 0.45	6.77 ± 0.40
V	52	4.83 ± 0.54	1.00 ± 0.02	1.4	6.94 ± 0.47	9.00 ± 0.42
VI	48	5.44 ± 0.50	1.22 ± 0.02	1.2	9.11 ± 0.46	12.02 ± 0.43
VII	44	5.73 ± 0.45	1.50 ± 0.03	1.3	12.22 ± 0.42	15.06 ± 0.39
VIII	44	7.57 ± 0.75	1.87 ± 0.05	1.3	15.28 ± 0.42	18.95 ± 0.47

* Ratio of head capsule width between successive instars.

above studies have been carried out in Kerala. Our studies have been made throughout the year and we have not observed any individual variations with regard to the number of instars in this insect. So it appears reasonable that *Opisina arenosella* indeed possesses eight larval instars in its life history as evidenced by the present studies. None of the above factors appears to have affected the number of larval stages and this is supported by head capsule values and their ratio (WIGGLESWORTH, 1972). It is to be noted that the authors mentioned except ANTONY (1962) have not stated the methods or materials they have employed ie., whether they are field observations or laboratory studies and if they are laboratory studies how they reared the larvae. Though the present method of rearing is uniform when compared to those of ANTONY (1962), who employed a number of methods for rearing the insect and the fairly large scale variation in his data is due apparently to the differing rearing conditions.

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BRIEF COMMUNICATION

A NOTE ON THE OCCURRENCE OF *ANOPHELES MINIMUS* THEOBALD IN MANIPUR

K. B. RAJPUT[1] & T. K. SINGH

Department of Life Science, Manipur University, Canchipur, Imphal, Manipur, India 795 003

(Received 2 August 1985)

Collection record with its resting place of *Anopheles minimus* Theobald, 1901, an important malaria vector of North East Region was reported for the first time from Manipur.

(Key words: record, *Anopheles minimus)*

Anopheles minimus Theobald, is one of the most dangerous malaria vectors in certain Southeast Asian countries and China. The species carries malaria in Burma, Formosa, South China, Indochina, Kampuchea, Vietnam and India. It plays an important role in transmitting malaria in Assam (VISWANATHAN *et al.*, 1941), hilly tracts of Bengal (IYENGER, 1940), Tripura (MISHRA & DHAR, 1955), NEFA (MISHRA, 1950), Jeypore hilly tracts of Madhya Pradesh (SENIOR WHITE, 1937; 1938) and in Singhbhum hilly region (SENIOR WHITE & DAS, 1938). The species has also been incriminated as malaria vector from Nagaland State (BHATNAGAR *et al.*, 1982).

The anopheline records of Manipur State reviewed by MORTIMER (1946) indicates the absence of suspected vectors of malaria of North East region i. e., *A. balabacensis* Baisas and *A. minimus* Theobald from records of earlier workers and from his own survey, for the State. Due to lack of any dissection record from the State there is no confirmed vector of malaria. In view of the above circumstances *A. minimus* Theobald which is well known malaria vector in adjoining Burma and States of Assam & Nagaland, has always drawn keen attention of the earlier and present workers (MORTIMER Loc. cit.) but till present, due to its absence from faunistic records it was out of expectation to be vector for Manipur State.

During recent years a survey work for mosquito fauna of Manipur was carried out and one female *A. minimus* Theobald specimen was collected from Moreh (150m MSL) on 19.viii.1984. The mosquito was collected from a shaded, slow moving nallah margin in dense shrubby forest area. Earlier reported domestic resting of the species from Assam (CHRISTOPHERS, 1933; THOMSON, 1941) were later on doubted due to lack of sufficient information on outdoor and window-trap collections. The outdoor resting of the species have also been pointed out from Jeypore hilly tracts of Madhya Pradesh (SENIOR WHITE, GHOSH & RAO, 1945) from China and variety *flavirostris* Ludlow, from Phillippines. From adjoining Burma, MACAN (1949), studied that the forested area

[1] Present address: Regional Tasar Research Station, Manipur, India 795 002.

Kabaw valley it is outdoor rester but in open cultivated plains it is indoor rester. In order to organise any effective malaria control programme in the State it is of prime importance to confirm the vectorial role and the species behaviour in the State.

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OBSERVATIONS ON SPIDERS (ORDER : ARANEAE) PREDACIOUS ON THE COCONUT LEAF EATING CATERPILLAR *OPISINA ARENOSELLA* WLK. (*NEPHANTIS SERINOPA* MEYRICK) IN KERALA : FEEDING POTENTIAL*

B. SATHIAMMA, S. P. JAYAPAL & G. B. PILLAI

Biological Control Laboratory, Central Plantation Crops Research Institute, Regional Station, Kayangulam, Krishnapuram, India 690 533

(Received 17 August 1985)

Twenty-six species of spiders belonging to twelve genera and six families were observed in association with the larval galleries of *Opisina arenosella* on coconut palms. Eighteen species were studied for their feeding potential under laboratory conditions. *Sparassus* sp., *Cheiracanthium* sp., *Rhene khandalensis* and *R. indicus* topped the list and *Neoscona elliptica* the last.

(Key words: Opisina arenosella, spider, coconut)

INTRODUCTION

A survey of the *Opisina arenosella* infested coconut gardens in Alleppey and Quilon Districts of Kerala revealed that twenty-six species of spiders belonging to twelve genera and six familes are frequently associated with the larval galleries of the pest (SATHIAMMA *et al.*, unpublished). Some of them were observed to be highly predacious and they consume a huge population of the pest in the field. The objective of the present study was to evaluate the feeding potental of the spider predators associated with caterpillars of *O. arenosella* in the laboratory.

MATERIALS AND METHODS

Test spiders were collected individually from *Opisina* infested coconut plantations. They were reared separately in glass jar cages (size 17 × 6.5 cm) in the laboratory. Coconut leaflet bits infested with known number of *Opisina* caterpillars were provided in each of the cages containing the spiders. The spiders were starved for a day prior to offering *Opisina* caterpillars to them. The number of caterpillars preyed upon and their feeding habits were recorded every day.

RESULTS AND DISCUSSION

All the eighteen spider species preyed on *O. arenosella* caterpillars (Table 1). The rate of predation varied from 0.05 to 1.54 caterpillars per day. *Sparassus* sp., *Cheiracanthium* sp., *Rhene khandalensis* and *Rhene indicus* recorded a high rate of predation, the rate being 1.54, 1.19, 0.71 and 0.70 caterpillars, respectiveiy, per day. *Neoscona elliptica* consumed only 0.05 caterpillars per day and occupied the last rank in the rate of predation. It was interesting to observe that the ratio of predation varied considerably between sexes of the same species. Females of *Sparassus* sp,, *Cheiracanthium* sp., *Rhene indicus* and *Marpissa dhakuriensis* consumed 1.54, 1.19, 0.70 and 0.62 caterpillars,

* Contribution No.481, Central Plantation Crops Research Institute, Kasaragod – 670 124, Kerala, India.

TABLE 1. Feeding potential of spiders predacious on *Opisina arenosella* capterpillars in the laboratory (Mean of 10 replications).

Sl. No.	Name of spider	Sex	Average no. of days observed	Average no. of prey consumed	No. of prey consumed per day
1	*Sparassus* sp.	F	70	108	1.54
		M	63	72	1.14
2	*Cheiracanthium* sp.	F	57	68	1.19
		M	66	46	0.70
3	*Rhene khandalensis* Tikader	F	38	27	0.71
4	*R. indicus* Tikader	F	46	32	0.70
		M	50	15	0.30
5	*Plexippus paykulli* (Aud.)	F	49	32	0.65
6	*Marpissa dhakuriensis* Tikader	F	89	55	0.6
		M	32	5	0.16
7	*Tetragnatha andamanensis* Tikader	F	65	38.5	0.59
8	*Cheiracanthium melanostom* Thorell	I	67	36	0.54
9	*Clubiona drassodes* Cambridge	F	28	12	0.43
10	*Larinia jayasankari* Biswas	F	78	31	0.40
11	*Marpissa* sp.	F	10	4	0.40
12	*Phidippus bengalensis* Tikader	F	48	18	0.36
13	*Phidippus* sp.	F	14	5	0.36
14	*Phidippus* sp.	F	9	3	0.33
15	*Marpissa tigrina* Tikdar	F	30	9	0.30
16	*Marpissa* sp.	F	10	3	0.30
17	*Rhene danieli* Tikadar	F	13	3	0.23
18	*Neoscona elliptica* Tikader Bal	F	20	1	0.05

F- female M- male I- immature stage

respectively, per day, whereas their male counterparts cosumed much less with 1.4, 0.7, 0.3 and 0.16 caterpillars per day. Rate of predation was observed to be very high when the prey caterpillar removed from the larval galleries were offered.

Spiders have been implicated as efficient biological control agents of pests of many agricultural crops. HOWELL & PIENKOWSKI (1971) listed spider fauna of Virginia alfalfa field and BAILEY & CADA (1968) on grain sorghum. Species of *Cheiracanthium*, *Clubiona*, *Marpissa* and *Phidippus* preyed on the maize borer larvae *Chilo partellus* and the consumption per predator varied from 2 to 18 borer larvae. *Clubiona* sp. and *Marpissa* spp. have been observed preying on the nymphs of *Pyrilla perpusilla* on sugarcane in Punjab (SINGH, 1967). JANDU (1972) observed *Marpissa* sp. and *Phidippus* sp. feeding on the

nymphs of *Diaphorina citri* on citrus. *Phidippus audax* (Hentz) consumed larvae of the boll weevil and salticid spiders on *Heliothis* spp. on cotton (WHITCOMB *et al.*, 1963). *Neoscona* sp. preyed on aphids *Myzus dycei*, *Chaitophorus kapuri*, *Liosomaphis himalayensis*, and *Metopolophium phaseoli* on leguminous host plants including *Urtica parviflora*, *Populus* sp., *Berberis* sp. and Indet respectively, and *Clubiona* sp. on *Aphis gossypii* on Indet plant (DAS & CHAUDHURI, 1983). *Neoscona nautica* Koch, *R. Khandalensis* Tikader and *Thomisus* sp. feed on aphids *Macrosiphum rose* and *M. rosaeiformis* on *Rosa* sp. (AGARWALA, 1983). A recent study MOHAMED *et al.*, 1982) of the natural enemies of the coconut caterpillar did not record any predatory spiders. The present report is the first record of the predacious spiders comprising major species such as *Cheirncanthium*, *Rhene*, *Marpissa*, *Neoscona* and *Clubiona* on the coconut leaf eating caterpillar *Opisina arenosella*.

The observations clearly revealed that the spiders constitute an important group of biocontrol agents exerting natural suppression on the field population of the coconut leaf eating caterpillar. *Cheiracanthium*, *Sparassus* and *Rhene* are the important predators consuming @ 0.7—1.5 *Opisina* caierpillars per day. The magnitude of pest suppression these species can exert can further be seen from their long life span and their presence in the field almost throughout the year (SATHIAMMA *et al.*, unpublished). During the period when *Opisina* population is very low, the spiders thrive on other species as well. Hence, conservation of these predators in the field is of great relevance. For the management of *O. arensella*, when chemical treatments are to be done care should be taken to use only those chemicals which are less toxic to the spiders. The major handicap with the spider fauna is that they are not specific predators of the pest, but are polyphagous ones and a such they would feed on many species of other insects as well available in the field.

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A NEW GENUS AND THREE NEW SPECIES OF ERIOPHYID MITES (ACARINA : ERIOPHYOIDEA) FROM WEST BENGAL INDIA

N. K. GHOSH & S. CHAKRABARTI

Biosystematics Research Unit, Department of Zoology,
University of Kalyani, Kalyani, India 741 235

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A new genus viz., *Indosetacus* under the subfamily Cecidophyinae and four new species of eriophyid mites viz., *Indosetacus rhinacanthi*, *Acaphyllisa pipera* and *Rhombacus eucalypti* are described from Purulia and Midnapore districts of West Bengal. Distribution, affinity and host-eriophyid relations of the new genus and species are also discussed.

(Key words: Acarina, eriophyids, taxonomy, morphology, new genus, new species, India)

In this paper one new genus and three new species of eriophyid mites are described. The type slides are deposited presently in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani, India 741 235.

Indosetacus gen. nov.

Body worm like. Rostrum and oral stylet short. Shield subtriangular, lacking anterior projection; dorsal tubercles at rear shield margin, setae directed caudad. Forecoxae contiguous, lacking an encircling line; sternal line short. Legs with all usual segments and setae, featherclaw simple. Thanosomal rings subequal dorsoventrally and completely microtuberculate but last few rings broader dorsally and not microtuberculated; ventral thanosome with all standard setae, female genitalia appressed to coxae; coverflap smooth: internal female apodeme short.

Type species: **Indosetacus rhinacanthi** sp. nov.

Remarks: Among the genera of Cecidophyinae, the present genus comes close to *Cosetacus* Keifer (1966), *Paracolomerus* Keifer (1975) and *Circaces* Keifer (1978) due to worm like body, shield without anterior projection, dorsal tubercles on rear shield margin and setae directed to rear. However, the new genus differs from *Cosetacus* by the presence of foretibial seta, sternal line and rear non-microtuberculated broad rings. It differs from *Paracolomerus* mainly by the absence of an encircling line on forecoxae and presence of rear non-microtuberculated broad rings and from *Circaces* by the presence of undivided body rings and third ventral setae.

1. Indosetacus rhinacanthi sp. nov. (Fig. 1)

Female: Body 86—109* long, 39–44 wide, worm like, whitish in colour. Rostrum 12—14 long, projecting forward; subapical seta short. Shield subtriangular without anterior projection, 21—23 long

* All measurements are in micrometers (μm).

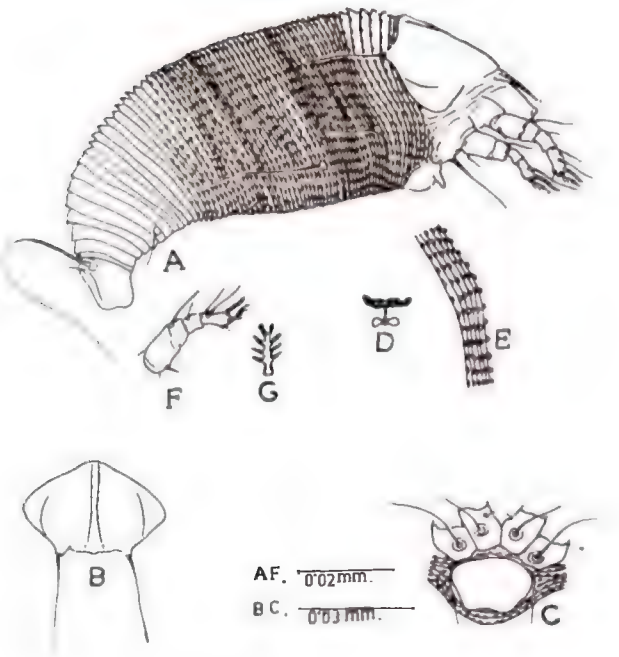

Fig. 1. *Indosetacus rhinacanthi* sp. nov.

Explanation of figures : A—Lateral view of mites; A_1—Dorsal view of mites; B—Anterior dorsum of mites; C—Coxae with female genitalia; D—Internal female apodeme; E—Side skin structure; F—Fore leg; G—Featherclaw.

and 35—37 wide; shield design represents only a few lines; median line absent; admedians complete; submedians absent; lateral lines occur on rear 0.5 part of the shield; dorsal tubercles on rear shield margin; dorsal setae 16—25 long, directed caudad. Foreleg 16—24 long from trochanter base; femur 8—10 long, seta 9 long; patella 3.4—4.6 long, seta 9—12 long; tibia 2—4 long, seta short; tarsus 4—6 long, with two upper setae, each 11—14 long and one short lower seta; claw 6—7 long knobbed; featherclaw simple, 4-rayed. Hindleg 14—22 long from trochanter base; tarsus with an upper seta, 14—16 long and lower seta absent; other characters as in foreleg. Forecoxae joined by a short sternal line; all the three coxal setiferous tubercles outlining by the curve lines. Abdomen with about 65—74 microtuberculate rings except rear 10—12 rings which are broad and nonmicrotuberculate; microtubercles round and located within ring margin. Lateral seta 9—12 long, on about ring 11; first ventral seta 28—31 long, on about ring 28; second ventral seta 3—5 long, on about ring 44; third ventral seta 14—16 long, on about ring 6 from rear; caudal seta 51—58 long; accessory seta 5—7 long. Female genitalia 16—19 wide and 11—14 long, appressed to hind coxae; coverflap smooth; genital seta 4—6 long. Internal female apodeme shortened in ventral view.

Male : Unknown.

Holotype : ♀, on slide (No. 710/1/85), INDIA : WEST BENGAL : Purulia, Manbazar,

15.i.1985 ex *Rhinacanthus nasuta*, (Acanthaceae), coll. N. K. Ghosh.

Paratypes : Many ♀♀, on the holotypic slide and on 5 slides (Nos. 711—715/1/1985), collection data as in the holotype.

Distribution : India : West Bengal.

Relation to the host plant : The mites make pouch galls on both surfaces of leaves. Cavity of galls are covered with white hairy outgrowths. During heay infestation, the entire leaf surface becomes twisted and distorted.

2. Acaphyllisa pipera sp. nov. (Fig. 2)

Female: Body 142—155 long, 40–46 wide, fusiform, brownish in colour. Rostrum 16—19 long, curved down; subapical seta 5 long. Shield trianguler with proximally pointed anterior lobe over gnathosome base, 35—42 long and 42—44 wide; shield design represents a few lines and granules; median line present indistinctly on anterior 0.25 part of the shield; admedians complete; submedians complete and directed to the lateral shield; shield granulated laterally dorsal tubercles ahead of rear shield margin, setae 4—6 long, directed up and centrad. Foreleg 24—30 long from trochanter base; femur 9—12 long, seta 7—9 long; patella 3—5 long, seta 21—25 long; tibia 5—6 long, seta 2—4 long; tarsus 5 long with 2 upper setae, 15—21 long and a short lower seta; claw 3—5 long, knobbed; featherclaw divided and 4-rayed on each side. Hind leg 22—26 long from trochanter base with usual segments and setae.

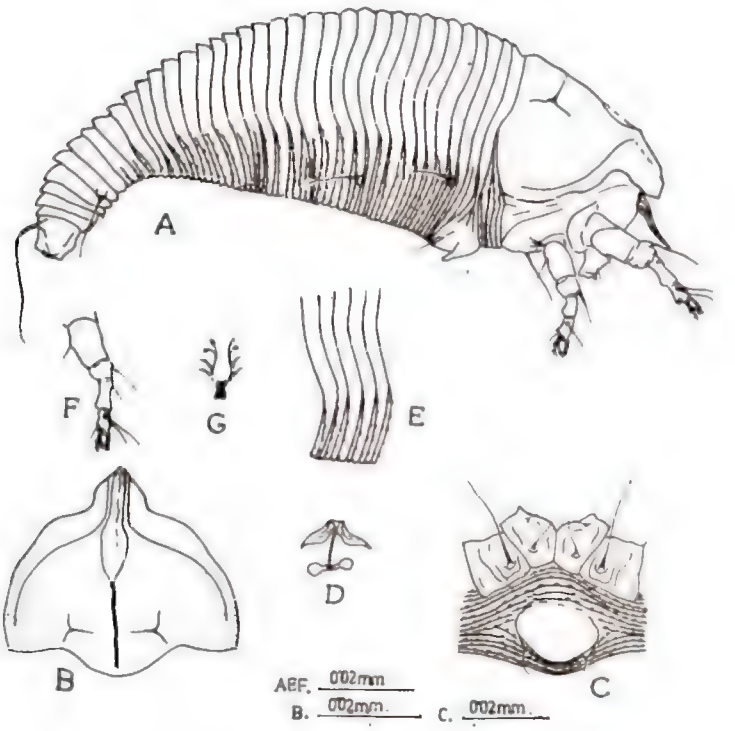

Fig. 2. *Acaphyllisa pipera* sp. nov.
For explanation of figures, see Fg. 1.

Forecoxae connate, sternal line distinct; both the coxae ornamented with lines and granules; first setiferous coxal tubercles at the level of anterior sternal end; second coxal tubercles a little ahead of the transverse line across third coxal tubercles.

Abdomen with about 35 smooth tergites and 72 microtuberculate sternites; microtubercles are rounded and present on ring margin; thanosome with a mid-dorsal longitudinal ridge which is fading gradually to rear. Lateral seta 8—9 long, on about sternite 10; first ventral seta 14—18 long, on about sternites 26; second ventral seta 7—9 long, on about sternite 42; third ventral seta 14–18 long, on about 5 from rear, accessory seta absent. Female genitalia 11—14 long, 16—18 wide; coverflap smooth; internal female apodeme moderate; genital seta 8—10 long.

Male : Unknown.

Holotype : ♀, on slide (No. 752/10/85), INDIA : WEST BENGAL : Purulia, Salpara, 1.ii.1985 ex *Piper betle* Linn., (Piperaceae), coll. N. K. Ghosh.

Paratypes : Many ♀♀, on the holotypic slide and on 5 slides (Nos. 753—757/10/85), collection data as in the holotype.

Distribution : India : West Bengal.

Relation to the host plant : The mites the ventral surface of leaves as simple leaf vagrants. Due to infestation, leaves turn brownish.

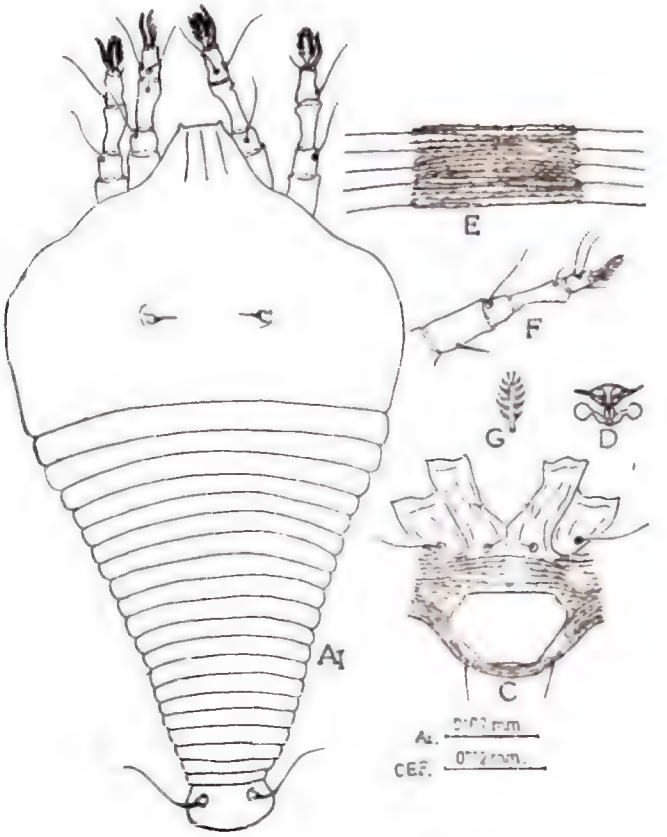

Fig. 3. *Rhombacus eucalypti* sp. nov.
For explanation of figures, See Fg. 1.

Remarks : This species is closely related *Acaphyllisa distasa* Keifer (1961) and *A. parindiae* Keifer (1978) by the presence of first setiferous coxal tubercles, granulated lateral shield and coxae. But differs from both the above species by the presence of proximally pointed shield lobe, number of rays in featherclaw and smooth genital coverflap. In addition, it also differs from *distasa* by smooth tergites and absence of accessory seta and from *Parindiae* by round microtubercles.

3. Rhombacus eucalypti sp. nov. (Fig. 3)

Female : Body 139—146 long, 70—74 wide, robust, flattened, rhombic form, brownish in colour. Rostrum 21—25 long, curved down; subapical seta short. Shield subtriangular, 53—56 long, 74—83 wide, with a broad anterior lobe; shield surface more or less smooth; median and admedians occur only in lobe area; lobe in dorsal view with 2 indentations; dorsal tubercles well ahead of rear margin, setae 5 long, directed up. Foreleg 42—44 long from trochanter base; femur 11—13 long, seta 16 long; patella 4—6 long, seta 16 long; tibia 10 long, seta short; tarsus 8 long and with 2 upper setae, each 16–19 long and a short lower seta; claw 7 long, simple; featherclaw simple, 6–rayed. Hind leg 37—39 long from trochanter base; tarsus 7 long with one upper seta, 18 long and a small lower seta; claw 8 long, simple; other characters as in fore leg. Forecoxae connate, sternal line short; first coxal setiferous tubercles set ahead of sternal end level; second coxal tubercles at the level of third coxal tubercles, second coxal setae very small.

Abdomen with about 18—22 broad, smooth tergites and 60 –70 microtuberculate sternites; microtubercles pointed and located within ring margin. Lateral seta 19—21 long, on about sternite 5; first ventral seta 21—26 long, on about sternite 20; second ventral seta 19 long, on about sternite 39; third ventral seta 28—30 long, on about sternite 6 from rear; accessory seta absent. Female genitalia 20—23 wide and 12—14 long; genital coverflap smooth; internal female apodeme large; genital seta 12 long.

Male : Unknown.

Holotype : ♀, on slide (No. 793/19/85), INDIA : WEST BENGAL : Midnapore, Hoomgarh, 27.ii.1985 ex *Eucalyptus globulus* Labill., (Myrtaceae), coll. N. K. Ghosh.

Paratypes : Many ♀♀, on the holotypic slide and on 4 slides (Nos. 794—797/19/85), collection data as in holotyye.

Distribution : India : West Bengal.

Relation to the host plant : This species is a leaf vagrant and inhabits on ventral surface of leaves. No remarkable damage symptom was observed though the population was heavy.

Remarks: So far, 3 species, viz., *Rhombacus morrisi* Keifer (1965), *R. asclepiadii* Keifer (1969) and *R. rheumella* Keifer (1970) are known under the genus *Rhombacus* Keifer (1965). The present species differs from all the above species in having 6–rayed featherclaw, smooth genital coverflap, short second coxal seta and by the shield design.

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EFFECT OF MATING DURATION ON FECUNDITY AND FERTILITY OF EGGS IN *BOMBYX MORI* L (LEPIDOPTERA : BOMBYCIDAE)*

M. THOMAS PUNITHAM, M. A. HANIFFA & S. ARUNACHALAM

Post Graduate & Research Department of Zoology, St. Xaviers' College, Palayamcottai, India 627 002

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Virgin *Bombyx mori* took 21 h to lay 176 eggs per individual and the percentage of hatching was nil. Mating duration upto 6 h reduced the preoviposition period and increased the total egg output by three times but subsequent increase in duration resulted in negative effects; it produced enhanced values in hatching upto three h duration. Increase in mating duration caused a decrease in body weight of females. Post oviposition life span was maximum (261 h) for virgin *B. mori* and decreased as a function of mating duration. Body weight of first instar progeny increased from 2.96 mg to 3.31 mg live weight with an increase in mating duration from 3 to 12 hrs.

(Key words: mating, preoviposition period, eggs, hatching)

INTRODUCTION

Mating in insects provides a stimulus for oogenesis (BENR, 1969; PICKFORD *et al.*, 1968) and oviposition (LEAHY & LOWE, 1967). GILLOT & FRIEDEL (1971) reported a linear relationship between number of matings and egg output (DAVEY, 1967; GORDON & BANDAL, 1967). Only a few reports are available on the effects of consecutive matings (SUBRAMANIUM *et al.*, 1980) and mating duration (SHAHI & KRISHNA, 1979) on total egg output and hatching in insects. But these reports do not reveal any information about the weight and life span of the mated female and/or the newly hatched young ones. The present investigation reports egg production, hatching, weight of newly hatched instars and weight and life span of female silk worm ***Bombyx mori*** as a function of mating duration.

MATERIALS AND METHODS

Healthy, fresh cocoons of *B. mori* of weight 1800 ± 100 mg were purchased from the State Sericulture Farm (Nannaharm, Tirunelveli, Tamil Nadu) and acclimated to Laboratory conditions. After emergence males and females were separated and the females were segregated into 13 groups, each containing 3 individuals. Test individuals of the first group (virgin) were allowed to lay eggs without mating. The females of the second and third groups were allowed to mate for 5 and 10 minutes respectively. Similarly for the succeeding groups, mating duration was increased by 10 minutes upto 1 hr, 120 minutes 3 h and 180 minutes upto 30 h respectively. After mating the male *B. mori.* was not allowed to mate another female and was discarded immediateely. Mated females were placed separately on rough brown sheets and were allowed to lay eggs by placing inverted plastic containers over them. The time taken by the imago after emergence till it started egg laying (preoviposition period) was recorded for each female. The number of eggs laid was counted and the percentage of hatching was calculated. After oviposition each female was

TABLE 1. Effect of mating duration on preoviposition period, egg output, hatching, postoviposition weight and life span and body weight of first instar in *B. mori*.

Mating time (min)	Preoviposition period (h)	Number of eggs laid	Percentage of hatching	Weight after oviposition (mg live wt)	Post-oviposition life span (h)	Body wieght of first instar (mg live wt)
0	21.4 ± 4.90	175.7 ± 12.47	0	736.3 ± 18.63	261 ± 29	
5	12.8 ± 2.60	143.3 ± 14.09	0	716.6 ± 16.27	237 ± 14	
10	11.8 ± 0.44	167.0 ± 11.77	0	709.5 ± 18.35	235 ± 5	
20	9.1 ± 0 61	202.7 ± 10.70	0	669.4 ± 18.10	198 ± 4	
30	9.0 ± 0.57	301.0 ± 14.37	0	554.5 ± 15.78	171 ± 28	
40	8.9 ± 0.49	342.1 ± 17.25	0	414.3 ± 19.24	145 ± 17	
50	8.7 ± 0.58	388.0 ± 13.29	0	332.7 ± 18.40	149 ± 4	
60	7.7 ± 0.62	407.3 ± 13.74	0	296.3 ± 11.34	131 ± 12	
180	7.9 ± 0.44	539.2 ± 23.50	82.5 ± 8.4	228.9 ± 11.17	128 ± 1	2.96 ± 0.14
360	7.9 ± 0.63	546.0 ± 25.50	88.6 ± 7.3	219.8 ± 12.92	124 ± 4	2.93 ± 0.13
540	9.2 ± 0.81	532.2 ± 9.50	96.7 ± 1.3	220.6 ± 14.72	129 ± 9	2.91 ± 0.19
720	12.4 ± 0.46	529.3 ± 10.21	81.6 ± 12.2	224.9 ± 15.81	151 ± 4	2.95 ± 0.18
900	15.2 ± 0.67	487.1 ± 17.84	91.2 ± 6.9	262.9 ± 16.94	140 ± 12	3.07 ± 0.17
1080	18.9 ± 0.12	462.3 ± 28.53	84.5 ± 7.3	320.0 ± 15.82	174 ± 12	3.14 ± 0.16
1260	21.3 ± 0.07	445.4 ± 19.26	77.8 ± 7.5	325.9 ± 12.32	156 ± 17	3.20 ± 0.14
1440	24.4 ± 0.06	433.7 ± 21.50	64.4 ± 8.0	335.5 ± 6.88	126 ± 19	3.29 ± 0.13
1620	27.8 ± 0.21	445.3 ± 17.70	66.1 ± 10.6	288.4 ± 23.72	168 ± 10	3.29 ± 0.18
1800	30.2 ± 0.43	380.1 ± 30.21	65.9 ± 6.1	221.2 ± 16.34	148 ± 17	3.31 ± 0.12
	$p<0.001$	$p<0.001$	$p<0.001$	$p<0.05$	$p>0.05$	$p>0.05$

Values represent the mean ± SD for the number of observations on the test individuals.

weighed in a monopan balance (sensitivity : 0.01 mg) and life span of the female was recorded separately.

RESULTS AND DISCUSSION

Virgin *B. mori* took 21 h to lay eggs after the emergence. Increase in mating duration upto 6 h reduced the preoviposition period and after that the time increased. Virgin *B. mori* laid 176 eggs/individual and the percentage of hatching was nil. The female mated for 1 h took the minimum time of 7.7 h to lay eggs. Mating duration increased the total egg output by 3 times upto 6 h (546 eggs/female) and subsequent increase in mating duration upto 30 h failed to produce any further significant increase in total egg output. Mating is not obligatory for either oviposition or egg production in *B. mori*. The complete failure

of hatching of eggs laid by the virgins shows clearly that insemination is essential for further development. Increase in mating duration produced enhanced values in hatching from 83% in females mated for 3 h to 97% in those mated for 9 h and thereafter subsequent increase in mating time caused a decrease in the percentage of hatching (Table 1).

Virgin *B. mori* showed the maximum live weight of 736 mg. Increase in mating duration caused a decrease in body weight of female to 220 mg when mated for 6 h to 30 h with slight fluctuations in between. Post-oviposition life span was maximum (261 h) for virgin *B. mori* and it decreased to 50 percent when mated for 1 hr and after that increase in mating duration produced elevated and reduced values in life span. First instar progeny of females mated for 3 to 12 h did not show much variation in their body weight. Maximum body weight of 3.31 mg live weight was noticed for the first instar larvae belonging to females mated for a maximum duration of 30 h.

Increase in egg production observed in mated *B. mori* as a function of mating duration supports the previous observations. For instance the number of eggs

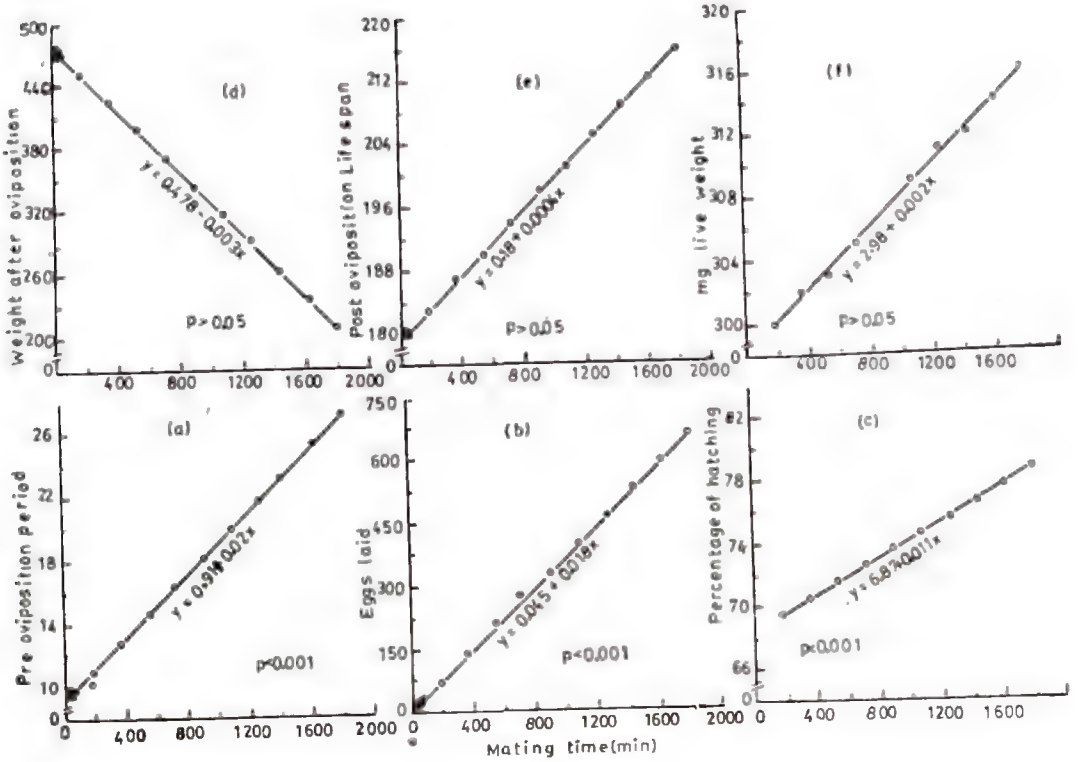

Fig. 1. Regressions and student's 't' as a function of mating time versus pre-oviposition period (a), egg output (b), hatching (c), post oviposition weight (d), life span (e) and live weight of first instar (f) in *B. mori*..

deposited by *Dysdercus koeinigii* increased from 14 to 218 per female with the increase in mating duration from 2 to 10 h (SHAHI & KRISHNA, 1979). The increase in egg production observed in mated female insects could be due to the fecundity enhancing substance of accessory secretion of male insects (GILLOT & FRIEDEL, 1977) and/or due to activation of corpus allatum (DAVIS, 1965).

Increase in mating duration from 3 h to 15 h produced elevated values in percentage of hatching and after 15 h, subsequent increase in mating duration caused negative effects such as decrease in egg output, hatching, post oviposition life span and post oviposited female body weight and increase in preoviposition period (SUBRAMANIUM *et al.*, 1980). The mated females lost considerable body weight (about 60%) and life span (about 50%) after oviposition and this loss appears to be relatively more when fertile eggs are laid. Since *B. mori* does not feed in the imaginal stage, it is possible to suggest that the decrease in body weight and life span as a function of mating duration could be due to energy expenditure and exhaustion. Regressions plotted (Fig. 1) confirmed that mating duration influenced preoviposition period ($p<0.001$), egg production ($p<0.001$), percentage of hatching ($p<0.001$), post oviposition weight ($p>0.05$) and life span ($p>0.05$) significantly.

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STUDIES ON HOST AGE PREFERENCE AND BIOLOGY OF EXOTIC PARASITE, *COTESIA MARGINIVENTRIS* (CRESSON) (HYMENOPTERA : BRACONIDAE)*

S. K. JALALI, S. P. SINGH & CHANDISH R. BALLAL

All India co-ordinated Research project on Biological Control of Crop Pests and Weeds, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore, India - 560 089

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Cotesia (=*Apanteles*) *marginiventris* (Cresson), a solitary endo-parasite was introduced in India for trials against tobacco caterpillar, *Spodoptera litura* (F.). In an effort to evaluate mass rearing technique, studies on host age preference and biology of this parasite were conducted in laboratory where the temperature was 27±1°C and RH 50-60 per cent. For oviposition, 3 to 5 days old larvae were preferred. Mean developmental period from oviposition to cocoon formation lasted 8.2±1 days and pupal period 3 to 4 days. Sex ratio was 1 : 0.25 (male : female). A single mated female was capable of parasitising on an average 91.3 larvae during its life span. Mean longevity of adult female and male was 5.3 ± 0.81 and 4.0±0.89 days respectively.

(Key words : host age preference, biology, *Cotesia marginiventris*, *Spodoptera litura).*

INTRODUCTION

Spodoptera litura (F.) (Lepidoptera : Noctuidae) is a serious polyphagous pest. It has been reported feeding on 112 species of plants belonging to 44 families (MOUSSA *et al.*, 1960). Indigenous natural enemies are not suceessful in satisfactorily suppressing this pest. Therefore, under All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds, *C. marginiventris* (MASON, 1981 has redefined the subfamily Microgastrinae and revived among others, genus *Cotesia* Cameron and placed the species *marginiventris* Cresson creating a new combination – *C. marginiventris* (Cress.); native of West Indies (MUESEBECK, 1921), was imported for trials against *S. litura* in 1981. Though, it was earlier introduced in India in 1969 (RAO *et al.*, 1971), no efforts were made to multiply it on a large scale for field evaluation. *C. marginiventris* is a major larval parasite of green clover worm, *Plathypena scabra* (F.) (MUELLER & KUNNALACA, 1979) in Arkansas, U. S. A. and S. Carolina (MCCUTCHEON & TURNIPSEED, 1981). BOLING & PITRE (1970) have studied life history and immature stages of this parasite on *Pseudoplusia includens* (Walker), *Trichoplusia ni* and *Heliothis virescens* (F.) and KUNNALACA & MUELLER (1979 on *Plathypena scabra* (F.). However, in India, information on host age preference and biology of *C. marginiventris* was not available. Therefore, these laboratory studies were conducted utilising tobacco caterpillar as a host.

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MATERIALS AND METHODS

Host insect, *S litura* was multiplied in the laboratory (average temperature 27±1°C & R H 50—60%) on an artificial diet (based on chick pea flour) developed for *Heliothis armigera* (Hb) by NAGARKATTI and SATYAPRAKASH (1974). Parasites used in the present study were obtained from laboratory where these are now continuously reared on *S. litura* larvae. Freshly emerged males and females of *C. marginiventris* in the ratio of 1 : 1 were held for 24 hours in glass vials (15 × 2.5 cm) for mating. Fifty per cent honey + water solution was provided on waxed paper strips inside the vials as adult food.

Host age preference :

Study was conducted by exposing one to ten days old *S. litura* larvae to *C. marginiventris* for 24 hours. 100 *S. litura* larvae of each age were released separately on castor leaves kept inside transparent plastic containers (20× 16 cm). In each container 4 (one day old) mated females of *C. marginiventris* were introduced. Each treatment was replicated 5 times. After exposure, parasitised *S. litura* larvae were collected and reared individually on artificial diet in glass vials (7.5 × 2.5cm). Each larva was observed daily for cocoon formation and subsequently cocoons were observed for adult emergence.

Biology

This study was conducted to determine developmental period (from oviposition to cocoon formation). Three day old larvae of *S. litura* were exposed individually to mated females of *C. marginiventris*. *S. litura* larvae were held with a camel brush and were exposed to mated females of *C. marginiventris* individually. Larvae were exposed to the parasite thrice a day – at 9.00 A M, 12 noon and 3 P M. Parasitised larvae were transferred on artificial diet in glass vials (7.5×2.5 cm). Larvae were observed for cocoon formation and subsequently cocoons were observed for adult emergence.

Fecundity and longevity :

This experiment was conducted by employing two methods. In the first method, 3 day old larvae were exposed to single mated female of *C. marginiventris* as described above. Larvae were exposed till female parasite stopped pricking. This was repeated daily till female died. This treatment was replicated six times. In the second method, fifty 3 day old *S. litura* larvae were released on foliage of castor leaves in transparent plastic container (20×16cm) to which a single mated female of *C. marginiventris* was introduced for 24 hours. This exposure was repeated daily till female died. This experiment was also replicated six times. After exposure to the female parasite, all the larvae were reared individually on artificial diet in glass vials (7.5×2.5 cm). Larvae were examined daily for cocoon formation.

RESULTS AND DISCUSSION

Host age preference :

C. marginiventris preferred 3 to 5 day old larvae of *S. litura*. Parasitism obtained for 3, 4 and 5 day old larvae was 67.2, 52.0 and 43.0 per cent respectively (Table 1). Percentage parasitism reached its peak on 3 day old larvae and after that there was gradual decline upto 10th day. Eight to 10 day old larvae were less preferred as compared to 1 day and 2 day old larvae. KUNNALACA & MUELLER (1979) reported that the 1st instar larvae of *P. scabra* were most preferred. BOLING & PITRE (1970) reported preference to 2 days old larvae of *T. ni*. KUNNALACA & MUELLER (1979) had also reported the increase of parasitism from 27.8 to 88.9 percent when exposed for one and 24 hours reseectively. Sex ratio obtained has also been furnished in Table 1. In general, higher percentage of females were obtained when 3 to 6 day old larvae were parasitised.

Developmental period:

Mean developmental period obtained from the time of oviposition to cocoon formation was 8.2 ± 1 days with more number of parastie larvae emerging on 8th day. Pupal stage lasted 3 to 4 days

TABLE 1. Host age preference of *C. marginiventris*.

Exposure time(h)	Age of the host larvae in days	Total number of host larvae parasitised out of 500 larvae	% parasitism	Sex-ratio of adults male : female
24 hours	1	23	4.6	1 : .06
	2	98	19.6	1 : .11
	3	336	67.2	1 : .24
	4	260	52.0	1 : .27
	5	210	42.0	1 : .26
	6	138	27.6	1 : .24
	7	66	13.2	1 : .24
	8	10	2.0	1 : .14
	9	7	1.4	1 : 0
	10	3	0.6	1 : 0

with 70 per cent adult emergence on 3rd day. BOLING & PITRE (1970) reported mean development time from oviposition to cocoon formation in case of *H. virescens* as 6 days and 7 days each in case of *T. ni.* and *P. includens.* KUNNALACA & MUELLER (1979) reported mean developmental time from oviposition to parasite larval emergence as 8 days at 30°C and 11 days at 25°C and pupal period as 3–5 days at 30°C and 4—7 days at 25°C in case of *P. scabra.*

Fecundity and longevity:

In the first treatment where larvae were exposed individually, 111.8 ± 16.8 (91 to 139) larvae were parasitised. In second treatment where larvae exposed on mass 70.8±10.4 (59 to 87) larvae were parasitised which was quite low as compared to individual exposure method. The longevity of adult female and male was 5.3±0.81 and 4.0±0.89 days respectively in presence of the host. ANONYMOUS (1984) reported that the adults lived for 15—18 days in presence of the host. However, in the present study not even a single female lived for such a long time. KUNNALACA & MUELLER (1979) observed the mean longevity at 30°C and 25°C as 5.6 nnd 9 days respectively.

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STUDIES ON THE HOST SELECTION AND DISCRIMINATION BEHAVIOUR OF *DIAERETIELLA RAPAE* (M'INTOSH), A PARASITOID OF *LIPAPHIS ERYSIMI* (KALT.)

S. C. DHIMAN & VINAY KUMAR

Entomological Research Laboratory, Department of Zoology,
M. S. College, Saharanpur, India 247 001

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The female *D. rapae* walks randomly on the aphid infested plant and discovers its host by macro-orientation. The higher host instars and the adult aphid show stronger defensive reactions in comparison to the younger ones. Contacts of the female parasitoid with aphid were recorded into three categories, 1. mere encounters; 2. encounters followed by ovipositional attempts; 3. encounters followed by actual oviposition. The alate stage of the host is found less parasitized while the half grown nymphal stages are more parasitized.

(Key words: Diaeretiella rapae, host selection, parasitoid, *Lipaphis erysimi,* oviposition, encounters)

INTRODUCTION

Diaeretiella rapae (Hymenoptera : Braconicae : Aphidiidae) has been reported as an internal parasitoid of mustard aphid, *Lipaphis erysimi* (Homoptera : Aphididae) from India by KUNDU *et al.* (1965). Later on, the parasitoid has also been reported from this aphid species by ATWAL *et al.* (1969) and DHIMAN and KUMAR (1983). KUMAR (1985) mentioned that *D. rapae* causes considerable mortality of mustard aphid and can be used as a bioagent in the control of this aphid. Though considerable amount of work has been done on this parasitoid by various workers, viz., ASKARI *et al.*, 1979; HAFEZ, 1960, 1961; SEDLAG, 1964; TAKADA, 1976, no studies have so far been conducted on the host selection and discrimination behaviour of the parasitoid and present investigations are an endeavour in this direction.

MATERIALS AND METHODS

At Saharanpur, *D. rapae* parasitizes the host *L. erysimi* on radish plant heavily in comparison to mustard and hence the former plant is selected for culturing the host aphid. The radish plants were cultivated in the earthen pots. The fresh plants were kept in wire gauze cages ($1 \times 0.5 \times 0.5$m) under field conditions during April, 1984. The aphids were cultured on these plants. The parasitoids were reared in glass vial on 30% honey solution separately at 22.5°C. The females of *D. rapae* were selected and kept together with the males in another separate vial to allow the mating. The male became exited by the presence of female within a minute and he approaches the female by tapping or touching her antennae or other body parts due to which the female became exited and allowed the male to mount on her back. Courtship behaviour lasted 30 to 120 seconds after which the male separated off. After mating, the females were taken out in separate vials using a small aspirator and fine camel hair brush and then transferred into the petridishes having all stages of the host on healthy radish leaf

pieces. Transfer of the parasitoids in the petridish was done by slight opening of the lid from one side and making the contact of the mouth of vial with the slit and plugging the rest of the slit with cotton wool. Thereafter, the vial and cotton wool were removed and the lid was closed. The observations on host selection and discrimination were made by using hand lens and under bionocular microscope.

To determine the host instar preference, 2 to 4 hour old mated parasitoid females were transferred on the population of host aphid, *L. erysimi*, in caged potted plant of radish at 25.2°C and 63.24% R H with photoperiod of 11.00 hours under field conditions. One mated and fully fed female parasitoid was released in each experimental cage. This is slightly advantageous because all stages of the host are present in large number and the influence of laboratory factors are practically excluded. Later on, the mummified aphids were collected from each cage and the percentage of various instars was determined. The data are recorded in Tables 1 and 2.

RESULTS AND DISCUSSION

The result of the observations, concerning with the host selection are presented below.

1. ***Host searching—D. rapae*** drums the radish leaf surace with her antennae while working. It is not yet known whether she detects her host by seeing, smelling or feeding. The parasitoid walks randomly on infested leaf surface and discovers its host by macro-orientation, ie., the antennae are held forward and slightly bent downwards. If the host, *L. erysimi* is tapped, the antennae are held upward and the parasitoid wasp may sting the host with her ovipositor and lay eggs. Oviposition takes place within less than one minute which makes difficult to determin what happened actually.

2. ***Host ability, mobility and suitability***— Defence reaction and modifications of the host against the parasitoid attack are rather feeble and they never influence the preference of different host instars by infestation. The higher host instars (IV and V) and the adult aphid show stronger defensive reactions using especially their legs, cauda, antennae and running off.

The female parasitoid prefers the moving aphid, i. e., showing slight movement. It was commonly observed that the female *D. rapae* ignored such aphids that were sitting entirely motionless on plant surface. It is a point of sigificance that the host aphids, *L. erysimi*, remain relatively immobile and however, they show feeble response of female parasitoid when sitting on the plant surface.

Contacts of the female parasitoid with aphids were recorded and divided into three categories:

1. Mere encounters.
2. Encounters followed by ovipositional attempts.
3. Encounters followed by ovipositional attempts and actual oviposition.

There is a difference in the number of encounters in different stages of the host (I to V instars and adults). The parasitoid makes random movements on the substrate, encounter with a host is only a matter of chance. There is also a great difference between various stages of the host encountered by the parasitoid. In the field conditions in most cases where the different stages of the aphid were present together in various colonies and if a colony is encountered by the parasitoid then the individual host stage of this colony will have more chance to be encountered, in place of other stages of the host.

TABLE 1. Preference of *Diacretiella rapae* to different stags of *Lipaphis erysimi*.

Particulars	Series—A			series—B			series—C			series—D		
	Apterous adult	young nymph	total	apterous adult	young nymph	total	apterous adult	young nymph	total	apterous adult	young nymph	total
Number of enocunters.	246	144	390	281	261	542	223	170	393	207	205	412
Number of encounters with another host with oviposition attempt.	136	77	213	110	123	233	100	85	185	101	80	181
Number off eegs deposited.	40	53	93	34	85	119	35	42	77	30	15	45
Number of exposed host parasitoid.	27	41	68	24	54	78	24	29	53	23	5	28

TABLE 2. Percentage of encounters, oviposition and egg deposition of *Diacretiella rapae*.

Partiulars	series—A		series—B		series—C		series—D	
	apterous adult	young nymph	apterous adult	young nymph	apterous adult	young nymph	apterous adult	young nymph
Percentage of total encounters.	63.08	36.92	51.84	48.33	56.76	43.25	50.23	49.73
Percentage of effectiveness of encounters.	16.21	36.80	12.09	32.56	16.59	24.70	14.49	7.32
Percentage of effectiveness of oviposition attempts.	29.41	68.83	30.90	69.91	35.00	49.41	29.70	18.75
Percentage of exposed host parasitoid.	27.00	41.00	24.00	54.00	24.00	29.00	23.00	5.00
Percentage of total egg deposited.	43.01	56.88	28.57	71.43	45.45	54.54	66.66	33.33

Having encountered the host, the parasitoid may either start oviposition or rejection of host may also take place without efforts to oviposit. The latter phenomenon occurred in 47.0—61.0% cases without any difference in various stages of the host. Perhaps, this rejection is due to some intrinsic factors of the parasitoid. The rejection may also take place after ovipositional attempts and it is different in various stages of the host. The effectiveness of encounters can be calculated by the following formula:

$$\frac{\text{Total number of actual oviposition}}{\text{Total number of encounters}} \times 100\%$$

$$= \frac{\text{Total number of eggs deposited}}{\text{Total number of encounters}} \times 100\%$$

From this calculation, it is proved that the effect of parasitization is different in various stages of host, i. e., for apterous adult ranged from 14.41 to 16.21% while the alate adults were even less affected 7.32% (Table 2). However, the nymphal instars were more successfully parasitized; the fraction of encounters in oviposition were 36.80% for the first and second nymphal instars, 32.56% for the third and fourth nymphal instars and 24.70% for the fifth nymphal instars. The parasitoid prefers to oviposit in the earlier stages of the host.

During the process of oviposition, wild movement, takes place by the attacked host to scare off the parasitoid. The effect of the movement increased with the development of the host stages. In the more advanced stages, host requires higher number of ovipositional attempt. The effectiveness of ovipositional attempts can be calculated by the following method:

$$\frac{\text{Total number of actual oviposition}}{\text{Total number of oviposition attempts}} \times 100\%$$

$$= \frac{\text{Total number of eggs deposited}}{\text{Total number of oviposition attempts}} \times 100\%$$

The effectiveness of ovipositional attempts decreased from high value 69.91% for half grown nymphal instar (III to IV) to 29.70 to 35.00% for apterous adult while in the alate adult it is only 18.75%.

The above results support the conclusion, that the frantic movements by the adult host attacked are more effective in scaring off the attacking parasitoid. Another thing is the ability of parasitoid to pierce the integument of the young host is more easy in comparison to hard and thicker integument of the advanced host.

The experiment shows that proceeding from small host to large host stages, the possibility of parasitization increases but the chance of being parasitized decreases. Due to this opposite effect, the half grown nymphal instars are being more parasitized than the other stages of the host. This experiment also indicates that if the hosts are parasitized at random, the process of oviposition and parasitism is not necessary, may be at random. Some stages of the same host species have more parasitism and more parasitoid eggs than some other stages.

The alate stage is only the stage which has less parasitization, few individuals are parasitized and fewer number of eggs are deposited in this stage. The alate aphids frighten away the parasitoid by wing vibrations and antennal movements or by kicking off or it may fly away to other place.

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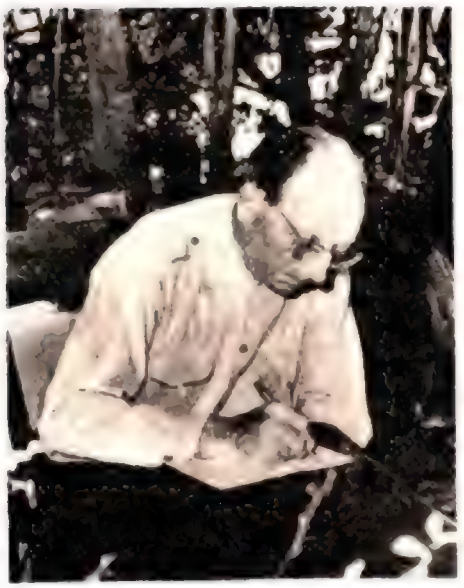
IN MEMORIUM

P. P. GRASSE (1895—1985)



Professor Pierre-Paul Grassé whose name is famous throughout the scientific world as the editor of the 37-volume *Traite de Zoologie* (a real encyclopaedia of Zoology, each volume comprising from 800—1000 pages or more, giving the most modern synthesis of our knowledge on the various animal groups from Protozoa to Primates), the founder of the international journal' *Insectes Sociaux*', the most eminent termitologist the world has produced, and who left his indelible impression on the diverse areas of biology he touched, breathed his last on 9th July 1985 at the age of ninety years,

Grassé was drawn indirectly to the study of termites through his earlier research (1924 onwards) on the flagellate Protozoa of the lower termites and the nature of this termite-flagellate symbiosis with special reference to its implications for their termite hosts. From then onwards the termites were for a period of half a century his most favourite area for research. This enabled him to bring out a 3-volume treatise *'Termitologia'* (2044 pages), of which the first volume appeared in 1982, the second in 1984 and the third, posthumously in 1986. There are no aspects in the biology of the termites to which he had not made important contributions. He had often stated that nothing can equal the close observations made on the animal in the natural *milieu*. This made him undertake several expeditions mostly to tropical Africa where the termite fauna is very rich in species as well as in their behaviovral diversity·

Grassé clearly demonstrated the importance of the proctodeal exchange of food (totally different from excrements) among the worker castes or workers and older larvae and its social implication as an important factor contributing to the maintenance of colony life. Digging into the very large cathedral-shaped mounds of *Macrotermes natalensis* in the African Savanas, Grassé was impressed by the great volume of the fungus gardens and of fungus combs each contained. His later studies establtshed the fact that the fungus combs along with the specific exclusively termitophilous fungus *(Termitomyces)* formed a regular part of the food of the fungus-cultivating higher termites (Macrotermitinae). Grassé and his student and close associate Noirot (1959) proved that the enzymes present in the fungi served to predigest the lignin of the fungus combs into easily digestible products. They also demonstrated that while the lower termites show symbiosis with their rectal flagellates, the fungus-cultivating higher termites show a ***double symbiosis***, firstly with the bacteria contained in their gut and secondly with the specific fungus *Termitomyces*, both enabling these termites digest their cellulosic diet. In 1978 at the age of 83 years (!), Grassè was the first to conclusively show the real nature of the fungus combs by demonstrating the existence of two types of transits through the termite intestine : one which takes place at a rapid pace, starting with the raw food and giving rise to the material with which the combs are made; the other at a slow pace, starting with the comb material (already partly digested by the fungi) which underwent normal digestion. Grassé and Noirot (1948) were also the first to report the process of formation of new colonies by the division of the existing colony into several groups and the development of each group into separate viable colonies, a process they termed *'Sociotomy'*

Termites, according to Grassé, are indefatigable movers of soil. The construction of epigeous mounds necessitates the bringing up of a considerable mass of soil from various levels underground. He has also been the first to point out (1950) the importance of termites in the origin and development of tropical soils.

The origin of polymorphism and caste differentiation in termites have always been problems to which Grassé gave much thought and he realised the great significance of these phenomena in the social life of termites as well as of the other social insects. The termites show great diversity in these processes and it was Grassè who reported the existence of *'achrestogonimes'* and of the *'pseudergates'* or the false workers. He also pointed out peculiarity of the soldier caste by showing their total dependence on the society (the workers or the older larvae) for feeding them, for the soldier is incapable of feeding by itself (1939). The study of the origin of polymorphism and caste differentiation in the higher termites (Termitidae) which defied all earlier efforts to yield satisfactory explanation, was successfully worked out by Noirot (1955) under Grassé's supervision.

Deeply convinced about the unity of the living world in spite of its extraordinary diversity, Grassé was the first to point out the essential common characteristics of all animal societies while at the same time giving due importance to their polyphyletic nature. He recognised that an interattraction of an olfactory nature among individuals of a colony forms the most important principle of

which all forms of social life is maintained. He also showed that social life would result in the emergence of new potentialities for the colony by its consequences on the individuals forming the colony as a result of what he called '*effet de groupe*' (group effect) (1946). In this phenomenon of group effect, Grassé asserted that the actions of congeners in a group act through specific sensory channels to modify the behaviour, physiology or even the course of development of individuals. Such complex interactions established among the members of the society bring about a true homeostasis through the action of social regulations (1949). For this the termites furnished him with the most appropriate examples, as such social regulations are operative particularly during the formation of the replacement reproductives as a result of the removal of the functional reproductives.

Grassé wondered how the blind worker termites possessing only limited behavioural repertoires and in which the isolated individual by itself is incapable of even continued existence, become capable when in a group, of constructions at times of very gigantic proportions, such as the mounds of *M. natalenis*, possessing a definite plan, a geometric shape and a specific architecture. Rejecting all metaphysical interpretations, for a long time he searched for a 'directing influence' and at last in 1959 arrived at the concept of '*stigmergy*'. This he deduced from his earlier observations on the reconstruction in *M. natalensis* of the royal cell, with the queen *in situ*. He found that the workers began to deposit pellets of earth haphazardly at a certain distance from the queen. Where the pellets of earth happened to form heaps, these now developed new qualities and meanings and acted as the foci for building behaviour, resulting in the construction of pillars. The workers finally connected the adjacent pillars with each other in such a way that it formed a continuous wall. It is thus seen that to begin with, the co-ordination of individual activities is *indirect*. It is the product of the work already completed which incites and directs further work until the whole species-specific product of the construction behaviour emerges. Grassé's studies (1981) on polycalic nests of *Apicotermes lamani* and of its construction behaviour led him to conclude that all collective functions such as nest construction or its repair and the regulation of such activities even in cases which necessitate a close co-ordination of individual acts and which may even show semblances of anticipated behaviour, are governed by very clear '*automatism*' (power of initiating vital processes originating at the cellular level) which he designated as *instinctive complexes*'.

Grassé never liked to be limited to just one or two specialisations in research. His insatiable curiosity urged him to take up research in diverse areas of the entire field of contemporary zoology & general biology including evolutionary biology and his nearly 400 publications bear ample testimony of his great versatility. He was an extraordinary promoter of new ideas and of new lines of research and used to make his students further pursue the new lines of research he had initiated. A protozoologist and cell biologist of eminence, Grassé was highly competent in the study of the ultra-structure of cell organelles, so much so, during the 1950s, an epoch when the use of the transmission electron microscope made possible the study of cell organelles and

structures at ultra–high magnification, the National Centre for Scientific Research (CNRS), Paris, gifted him with an electron microscope laboratory which formed the nucleus for ultra–structural studies by a distinguished group of researchers under his direction.

The several expeditions which took Graseé to the heart af tropical Africa for the study of the biology of termites, also enabled him to develop a passion for primatology. There in Gabon he founded in 1967 (?) the 'Laboratory of Tropical Biology' where groups of research workers carry out studies on the psychology and behaviour of the anthropoid apes and on the behaviour of various other animal groups.

But the discipline which Grassé most preferred and in which his contribution was most prolific was that of ethology and the psycho–physiology of the social insects, for which he suceeeded in forming a strong French school of researchers. At the Internationanl Congress of Entomology, Amsterdam (1951) he founded the '*International Union for the Study of Social Insects*' and he and Professor Gösswald (Würzburg, FRG) took the initiative for forming a separate section for Social Insects at international congresses. In 1954 he again was the prime moving force for starting the prestigious journal '*Insectes Sociaux*' which has by now published 33 volumes.

On the occassion of Prof. Grassé's retirement on 30th September 1967, his friends, colleagues, admirers and past an present studeuts celebrated his 50 years of very distinguished service in the cause of science, under the presidentship of the Minister of State in charge of scientific researh. There he declared that he shall continue his research, his writing and editing work and that his mind is full of new projects but of which he is not sure of accomplishing all. In January 1982 at the age of 87 years he wrote to me (his doctoral student of 1954—58) : "I shall continue to work till there is life left in me".

It was but natural that Grassé's fame spread far and wide. He became the unnamed ambassador abroad of the french scientific and teaching community. He was the highly respected President of the prestigious Academy of Science, Paris, the Honorary President of the 'Societé Entomologique de France', An Associate Member of the Royal Academy of Belgium, Vice–President of the International Congress of Zoology and Honorary Member of the International Congress of Entomology. The Universities of Brussels and of Gand awarded him the degree of Doctor of Science *honoris causa*. Wherever he went outside France, his fame and reputation preceded him. He was invited to visit most of the european countries where his learned audiences benefited from his inexhaustible fund of knowledge. In Brazil, the scientific community received him most enthusiastically and his lectures elicited such great admiration and respect that several Brazilian collaborators accompanied him to his laboratory in Paris to work under his enlightened supervision. The International Congresses of Zoology and of Entomology held in the U. S. S. R., the U. S. A., Denmark, Germany, England, Canada and elsewhere listened to his talks with great interest and admiration.

Pierre–Paul Grass'e was a very enthusiastic professor, dynamic speaker, a born naturalist who loved equatorial

Africa, researcher of eminence, methodical and perseverent observer, alert writer and editor, severe critic and a true patriot of his great country and an exponent of its great cultural heritage. He shall be remembered as one of the greatest biologists France has produced, and without exaggeration, as one of the greatest zoologists of all time. May his noble example of devotion to scientific research and the dedication of his entire life-time to the advancement of biology serve to inspire us all.

K. J. JOSEPH
Professor & Head of the Department of Zoology, University of Calicut, Calicut University P. O., Kerala, India 673 635

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BOOK REVIEW

INSECTS AND MITES OF CROPS IN INDIA. by M. R. G. K. NAIR, Publication and Information Division, Indian Council of Agricultural Research, New Delhi, 1986, 408 pp., Figs. 301, Price Rs. 42.50.

This is the revised edition of the book published earlier in 1975. In this edition is included a considerable amount of information on the insect and mite pests of crops in India and their control which has accumulated since the date of its first publication. A new chapter on pests of fodder crops and a new section on pests of Cacao also have been added. A list of scientific names arranged alphabetically is a new feature of this edition. With the revision, the value of this book as a reference book on crop entomology and acarology in India has increased.

A. VISALAKSHY

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I, V. K. Kesava Prabhu, hereby declare that the particulars given above bove are true to the best of my knowledge and belief.

(Sd./)

Trivandrum,
March 31, 1987.

Dr. V. K. KESAVA PRABHU
Publisher, *Entomon*.

ANNOUNCEMENTS

IV Oriental Entomology Symposium

The IV Oriental Entomology Symposium is being planned to be held in November 1988 in Agra. There will be scientific sessions and workshops on specific topics. Scientific sessions will have the following major sections : insect systematics, morphology and ultrastructure, biology and ecology, physiology, medical and veterinary entomology. It is also planned to have workshops on specific themes and topics like insect behaviour, social insects, insect control, high altitude biology, Agromyzidae, Chironomidae, parasitic Hymenoptera, host specificity and host selection etc. Facilities will be provided for organising workshops on specific themes of importance. Those who are interested in participating should contact Dr. Ipe M. Ipe, Convener, IV Oriental Entomology Symposium, School of Entomology, St. John's College, Agra.

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V All India Symposium of Invertebrate Reproduction

V All India symposium of Invertebrate Reproduction will be held at P. G. and Research Department of Zoology, Arulmigu Palaniandavar College of Arts & Culture, Palani, Tamil Nadu during the 4th week of September, 1987. It is being organized by the Indian Society Invertebrate Reproduction. Contributions in any area of invertebrate reproduction are welcome. One of the focal themes proposed in the symposium is the productive biology of invertebrates (Aquaculture, Sericulture, Apiculture etc).

For further details write to :

Prof. Dr. S. PALANICHAMY, Convener,
V All India Symposium of Invertebrate Reproduction,
P. G. & Research Department of Zoology, Arulmigu
Palaniandavar College of Arts & Culture, PALANI,
Tamil Nadu – 624 602

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